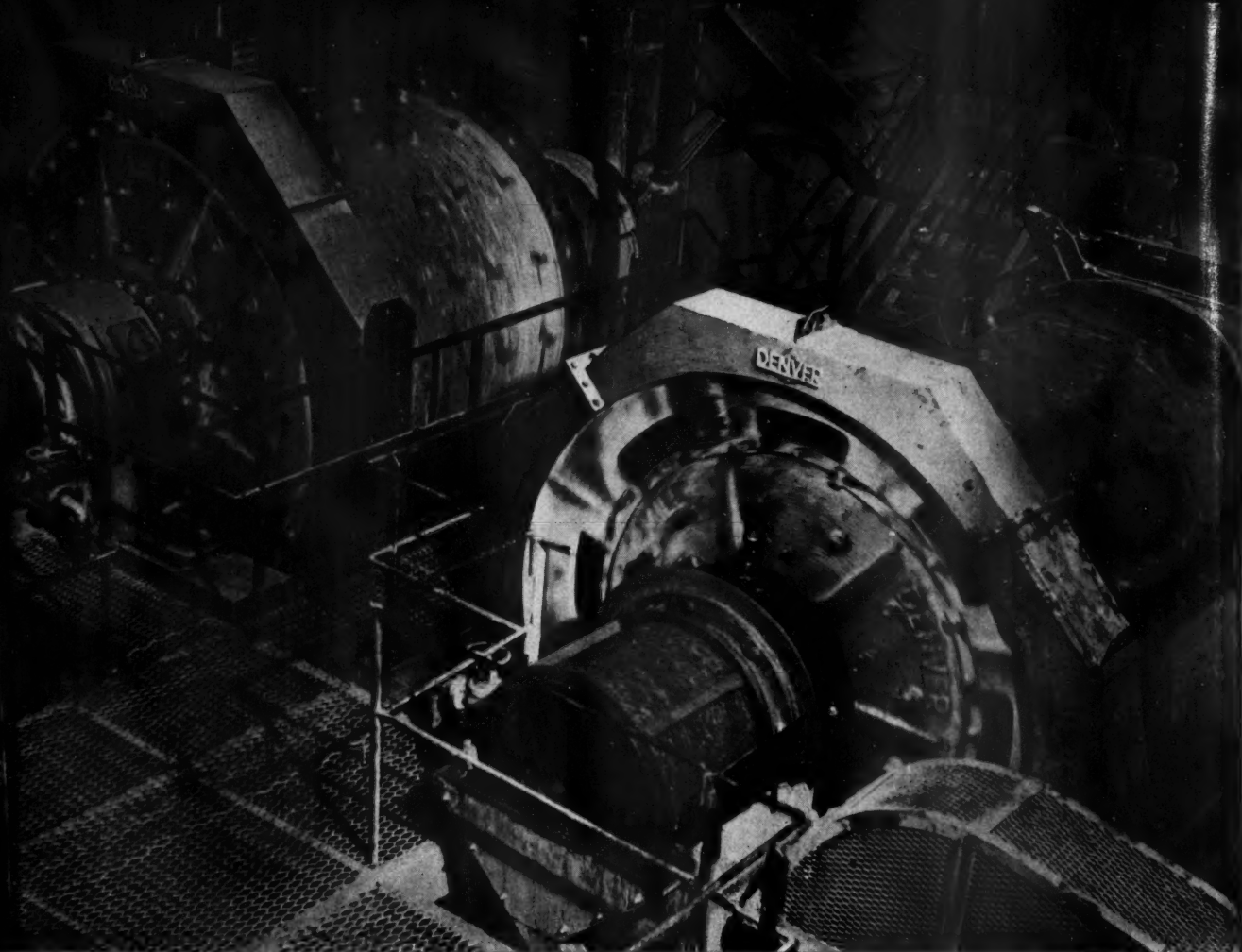


MINING CONGRESS JOURNAL



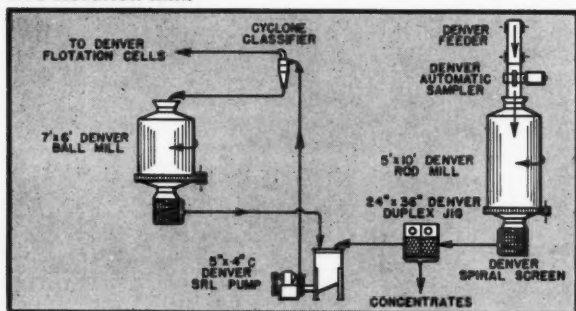
SEPTEMBER 1961





Modern Concentrator Selects 500 TPD DENVER Mills

This DENVER Rod Mill—Ball Mill grinding team is in operation at a new 500 ton-per-day, base metal, selective flotation mill.



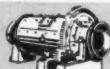
Preliminary Grinding Tests Without Charge

Mill size and specifications are determined by experienced engineers who study your grinding problem in detail and take into account the effect of grinding on your total milling circuit. Laboratory testing facilities are available to assist in proper mill selection.

Mill sizes (up to 10' dia. x 20' long) and type best suited for your grinding needs are described in Bulletin No. B2-B34.



"The firm that makes its friends happier, healthier and wealthier"



Steel-Head Mills



"Sub-A" Flotation



Agitators



Diaphragm Pumps



Automatic Samplers

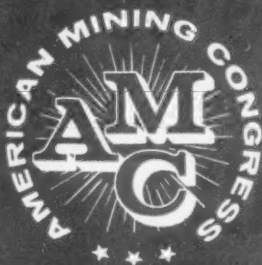


SRL Pumps

Complete Mineral Processing Equipment

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ON OUR COVER

O'Donnell #2 mine of Rochester & Pittsburgh Coal Co. at Gilmer, W. Va., was started in 1956 and went into production in 1959 to eventually replace 1,000,000 tons of production from the company's central Pennsylvania mines. Operating in 72-in. of Pittsburgh seam coal, the mine produces low sulphur steam coal and metallurgical grades. Last year's output was over 550,000 tons.

Published Monthly. Yearly subscriptions, United States, Canada, Central and South America, \$3.00. Foreign, \$10.00. Single copies, \$0.75. February Annual Review Issue, \$1.25. Second class postage paid at Washington, D. C., and at additional Post Office, Lancaster, Pennsylvania.



ANOTHER NEW KENNAMETAL* BIT :

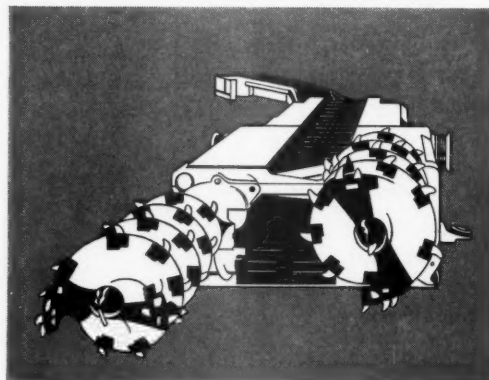


... specially designed for low coal auger-type continuous miners

Here are four advantages you get with the new U23P Kennametal cutter bit:

- 2" gage cuts greater clearance
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Prove in your mine how the new Kennametal U23P cutter bit will cut coal faster. Let the quality and design show up in performance—more tons per shift. Call your Kennametal Representative or contact us direct. KENNAMETAL INC., Mining Tool Division, Bedford, Pennsylvania. Phone: 623-5134.



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... Partners in Progress

THIS MONTH

—MCJ Presents —and the

SESCO NO. 1

Southern Electric Generating Co., a southern Alabama utility company, has opened a coal mine with a capacity of 1,500,000 tons per year. The authors describe development of the mine, from exploration to the selection of underground equipment, and construction of a modern 750-tph coal preparation plant. The article begins on page 30.

PROGRAM FOR MAINTENANCE OF MOBILE EQUIPMENT

The need for an effective maintenance program is recognized by every manager, but all too few devote the time and effort needed to bring the maintenance problem under control. This is a real challenge that begins with recognition of the problem. See page 35 for details.

UNDERGROUND CONVEYOR BELTING IN THE UNITED KINGDOM—Part I

Safety has been promoted by the reduction of mine conveyor belt fires in the United Kingdom. The problem of determining the causes of belt fires and the development of nonflammable belts is described. With 5500 miles of conveyor belting under National Coal Board's supervision, a program of improving belt design has led to a considerable savings in mine costs. Page 40.

CUTTING COSTS THROUGH OPERATIONS RESEARCH

Neither operations research nor modern computers can replace the common sense of an experienced and alert manager, but the techniques of operations research can be effectively used in analyzing all kinds of mining costs. Practical ways for putting OR to work are discussed in the article beginning on page 45.

(Continued on page 5)

AUTHORS

James E. Brown, Jr., manager of coal operations, Southern Electric Generating Co., joined Southern Electric in 1958. Before that he was superintendent of the Deerfield mine, Poca-hontas Fuel Co. for 4½ years and had worked



J. E. Brown



G. C. Dyer

as an engineer for the Cardox Corp. Grosvenor C. Dyer is vice president of mining operations, Alabama By-Products Corp., having joined in 1953 as superintendent of the Maxine mine. Before that he was operating vice president of Stith Coal Co.

For the past three years Howard Hanks has been operations engineer for Marquette Cement Manufacturing Co., working on maintenance, plant start-up and operating problems. He was previously with E. I. duPont Co. for two years and before that was with Lone Star Cement Corp.



for ten years, serving for five years as assistant plant superintendent.



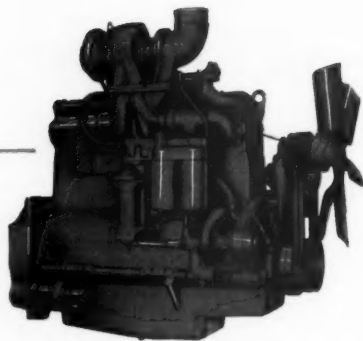
S. Weinberg, a research and development specialist, joined the National Coal Board in 1955 as deputy chief engineer (technical) and since 1958 has been chief engineer (specialist services). He has had extensive experience in research and development with marine engines, power station equipment, helicopters, compressors, etc., and was for three years lecturer in engineering at the University of Leeds.

James L. Cox has been with International Minerals & Chemical Corp since 1951. He joined the company as project engineer and advanced through several positions to become manager of minerals operations at the company's Florida phosphate complex. He is currently on special assignment managing a major expansion program for the company.



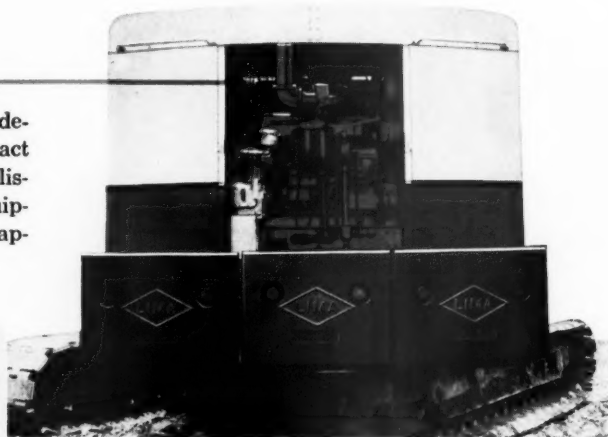
THE 21000 DIESEL

The Allis-Chalmers 350-hp, turbocharged 21000 diesel is gaining acceptance at an ever-increasing rate. For each new installation adds still more evidence of its remarkable efficiency — efficiency that passes along an 8- to 27-percent saving in fuel wherever it's used.



MOVES IN...

The new, controlled-turbulence, open-chamber design packs maximum horsepower into a compact package . . . greatly simplifies installation. Allis-Chalmers engineers work closely with the equipment manufacturer on adaptation and proper application of the engine.



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Here in this 4½-yd Type 1250 Lima dragline, the 21000 engine adds still further to its reputation. Fuel savings have been as expected. And as for ability to get the job done, its responsiveness and acceleration have been outstanding.

Performance like this has led many manufacturers to standardize on the 21000 and other "Thousand Series" diesels. Get full information from your dealer or direct from Allis-Chalmers, Milwaukee 1, Wisconsin.

BC-37

The 21000 also is offered in the Lima Type 803.

ALLIS-CHALMERS



RECENT PROGRESS IN THERMAL DRYING ULTRA FINE COAL

Minus 28-mesh coal in the form of filter cake is being efficiently dried in a recently constructed thermal drying plant in Turkey. The plant is handling as much as 150 tph of filter cake containing up to 30 percent surface moisture in a "flash dryer." See page 47.

ECONOMICS OF DEEP-SEA MINING

Whether or not mineral deposits at the bottom of the oceans can be mined at a profit remains to be seen, but on paper deep-sea mining appears to be both technically and economically feasible. Manganese nodules are the most promising material for exploitation. They could be recovered by either a drag or hydraulic dredge. See page 52.

INTERCONNECTION OF HOIST AND CROWD CONTROLS

With the development of larger and more expensive shovels and draglines, it has become increasingly important to achieve maximum production from these units. Interconnection of hoist and crowd controls is described as one of the means for improving the efficiency of these machines. Comments from two shovel manufacturers provide knowledge of field trials with interconnected hoist and crowd controls. See page 60.

POINTERS FOR IMPROVEMENT OF UNDERGROUND DRILLING TECHNIQUES

Maximum drill performance is not a matter of chance, and a technique that works at one mine might not work at another. Homestake Mining Company's drilling research program has brought solutions to problems experienced by nearly every mine operator, as outlined in the article starting on page 66.



Raymond E. Zimmerman, vice president, Paul Weir Co., has spent seven years as a mining consultant for this company. At one time he was professor and chief of the Mineral Preparation Department at Pennsylvania State University, and has world-wide experience in coal preparation.

John L. Mero has for the past four years been doing research on the economic and technical aspects of recovering minerals from the ocean. For the past year he has been continuing his work on a D. C. Jackling Fellowship. Mero holds a doctorate in engineering from the University of California.



A. M. Vance, an electrical engineer, joined Westinghouse in 1943 and worked for 13 years in the Motor Engineering Department gaining extensive experience with d-c motors, generators, and regulators for the mining industry. Since 1956 he has been a member of Mining, Petroleum & Chemical Section of the Industrial Engineering Department. He has specialized in the control equipment used on open pit equipment.

William C. Campbell was with Homestake Mining Co. for 12 years before joining Wyodak Coal & Manufacturing Co. in 1942. In 1945 he returned to Homestake as chief mine surveyor and for the past ten years has been assistant mine superintendent.

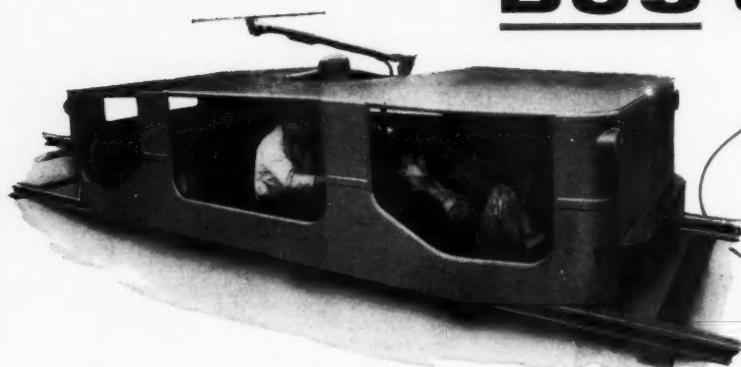


coming and going

every
you take your profits on ~~the~~ run

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BUS & JITNEY



Lee-Norse

MINE PORTAL BUS

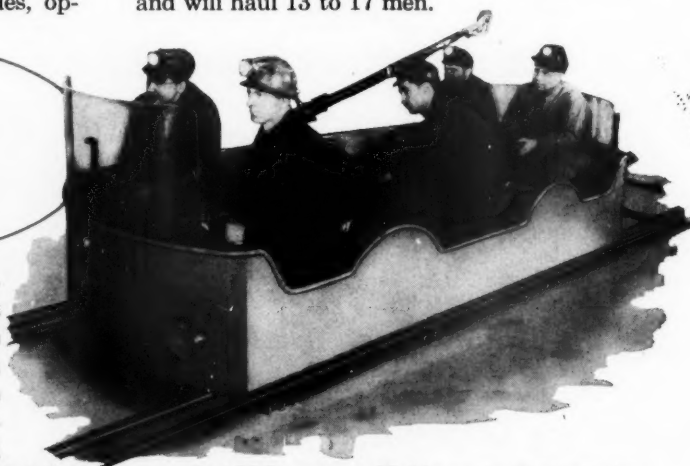
■ There's no wasted motion with this self-propelled Portal Bus because it is fast on the take-off, saving manpower time for conversion into more tonnage. And it is designed for safety, with hydraulic operated running brakes plus mechanical emergency and parking brakes direct on the wheels. For severe grades, op-

tional electric dynamic system produces braking effect from the motor for *extra* safety under all conditions. Also the split roof construction gives operator unimpeded, all directional view, while the trolley pole is always within quick reach. This bus is powered by 15 H.P. motor and will haul 13 to 17 men.

Lee-Norse

MINE JITNEY

■ The Mine Jitney is the "Jack-of-all-Trades" of the mine fleet because its versatility enables it to be used on the regular job and for emergency. It can handle the job of furnishing fast, safe transportation of key personnel, maintenance crews and special groups; and can double up as an ambulance or fire-fighting equipment car. Designed with twin braking systems for added safety. Powered with either



5 or 7½ H.P. motor. Holds up to 7 men comfortably. Optional equipment: Plexiglas windshield, fire extinguisher, stretcher equipment.



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It pays to use LeTourneau-Westinghouse graders in your pit. First of all, they step-up production because they handle so many jobs that increase your overall pit efficiency (see panel at right). Second, because of their *extra speed and dependability*, LW graders handle your "housekeeping" duties *faster*... you need *fewer* maintenance machines.

With any straight-shift LW grader you get 5 to 9 more full-power gear ratios (including reverse) than with any other make. You work 1 to 7 mph faster... complete up to 28% more blade-work per day! Or, use a POWER-Flow® 550 or 660, and you get infinite speeds up to 26 mph, with torque converter automatically matching speed and power to load.

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- Regular, more frequent maintenance of haul roads
- Quick clean-up after blast
- Clean pit floors
- Maintain work-areas around plant
- Keep stockpile toes pushed in
- Keep dumps smooth and level
- Clean ore benches of washed-down dirt
- Assist exploration teams
- Keep drainage open

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LETOURNEAU-WESTINGHOUSE COMPANY, PEORIA, ILLINOIS

A Subsidiary of Westinghouse Air Brake Company

Where quality is a habit



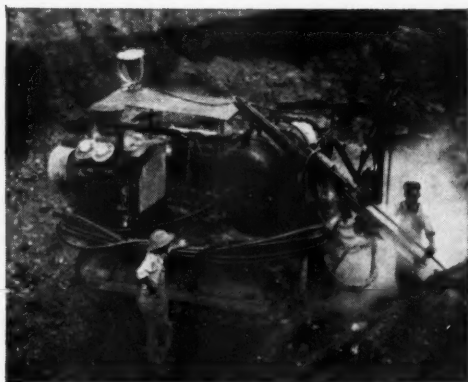
AT THE HEART OF INDUSTRY...



Serving the famed Moss #3 Mine of Clinchfield Coal, Duty, Va., 48"-wide U. S. Rubber MineHaul main haulage belts, each more than a half a mile long, carry 3,000 tons each per shift. These belts, in turn, are fed by a number of 36" panel belts. The fact that most of the belting used in this six-million-tons-a-year mine was made by US reflects U. S. Rubber's position as the world's leading authority on conveyor belting.

CB 101

At the heart of the coal mining industry, you'll find US... with the industrial rubber products that provide "minimum mining maintenance." See how and why U.S. Rubber products serve you better, cost you less, throughout your entire mining operation.



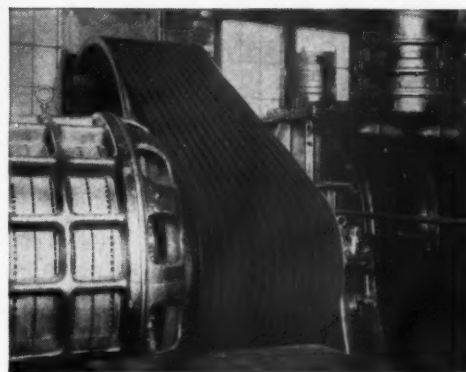
Long after other hose have failed from the cuts, abrasion, and abuse of heavy-duty work, U. S. Matchless® Air Hose can be seen powering equipment at mining and construction sites everywhere. Its unique ability to withstand the toughest treatment is but one reason why U. S. Rubber is the largest producer of hose in the world, with a complete line of hose for every industrial need.

H 101



Dramatically reducing maintenance and down-time for conveyor belt installations everywhere, patented U. S. Searle Sleeves protect rollers against impact damage, corrosion, build-up of wet muck, fines, and abrasive dusts. Belt wander is eliminated, edge wear greatly reduced, troughing substantially improved. Both belt and idler rollers wear far longer.

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Cut costs, reduce maintenance, avoid shutdowns.

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United States Rubber

MECHANICAL GOODS DIVISION

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The **H & P Vibroplane**, a product of Reineveld of Holland, recognized world leaders in centrifugal equipment, is now proving its advanced performance features by handling a variety of coal sizes in American preparation plants.

The new **H & P Cyclo-Cell** for froth flotation, received with unusual interest, has a novel hydro-pneumatic principle of operation which permits unequaled simplicity of design and offers these outstanding advantages:

- No moving parts in the Cell, yet more aeration and agitation.
- Combination of high recovery and exceptional ash reduction.
- Low operating cost.
- No mechanical maintenance in the cell.
- Ease of installation.

For truly superior performance select H & P Cyclo-Cells—the newest product of Heyl & Patterson's engineering skill, backed by years of experience in creating better preparation equipment for the coal industry.

The New H & P Vibroplane:

- is designed to handle large tonnages (in actual operation, the feed rate exceeds 100 TPH).
- is capable of handling a wider range of coal sizes—(for instance $\frac{3}{8}$ " x 0 without desliming, also stoker sizes, or anything in between).
- has higher G-forces and greater screen surface area—therefore must produce consistently a product with lower moisture. (Surface moisture in stoker sizes approaches the 2% mark; $\frac{3}{8}$ " x 0 product heavily loaded with fines minus 28M is dried below 10%).

Other outstanding features are the high rate of recovery, low power requirements, and the low rate of degradation.

The H & P Vibroplane—a Coal Drying Centrifuge for the widest variety of jobs, belongs in the preparation plant where only the best all-around performance will do.

For proof, call in your H & P Contracting Engineer.



HEYL & PATTERSON, inc.

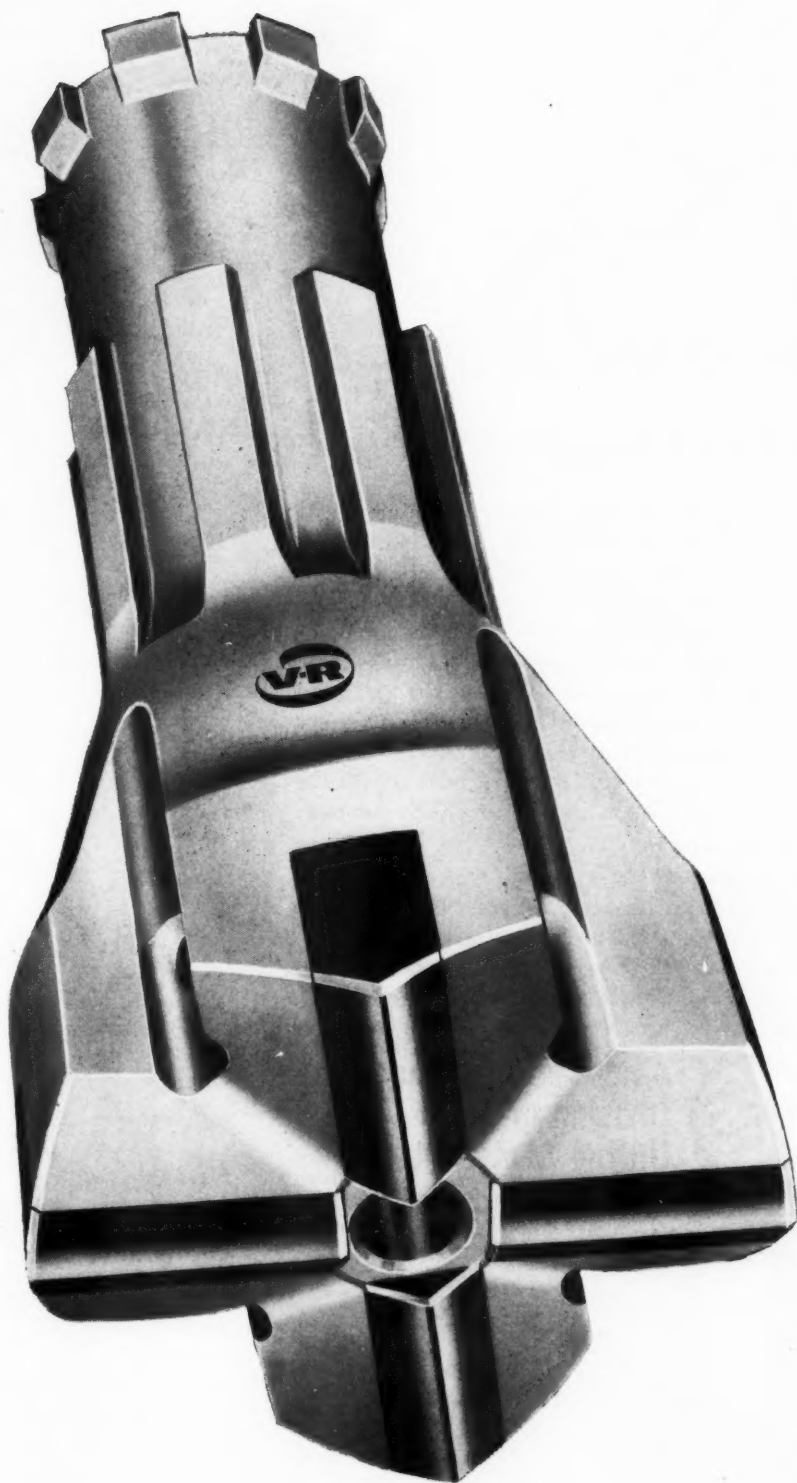
55 FORT PITT BLVD., PITTSBURGH 22, PA.

Other familiar H & P Preparation Equipment: The H & P Cyclone

The H & P Sieve Bend

The H & P Fluid Bed Dryer

The Reineveld Fine Coal Dryer



More bite goes

DOWN THE HOLE

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This mark tells you a product is made of modern, dependable Steel.



TIGER ON THE SPOT AT PEABODY COAL COMPANY

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This 32-cubic-yard dragline operates around the clock digging overburden at Peabody's Airline Mine, near Linton, Indiana. It is rigged with a pair of 2½" USS Tiger Brand drag ropes 275 feet long. These are subject to severe abrasion and heavy shock loads . . . but they last from 700 to 800 hours.

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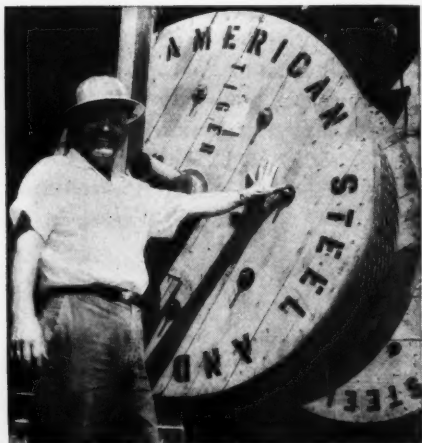
Put the Tiger on the spot! Where you have a large variety of wire rope applications, the Tiger Brand Field Service Representative can be of great help. Call him in to make a check of your equipment. The chances are he can save you money. His services can be obtained through your local Tiger Brand distributor or by writing direct to American Steel and Wire, Dept. 1223, Rockefeller Building, Cleveland 13, Ohio.

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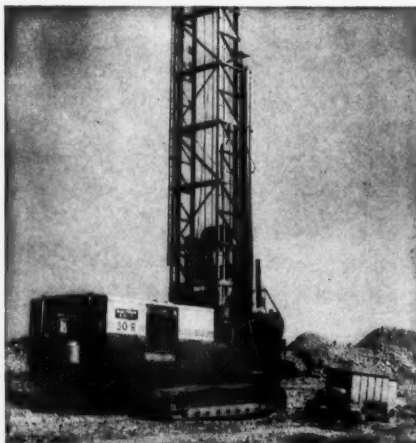


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Division of
United States Steel**

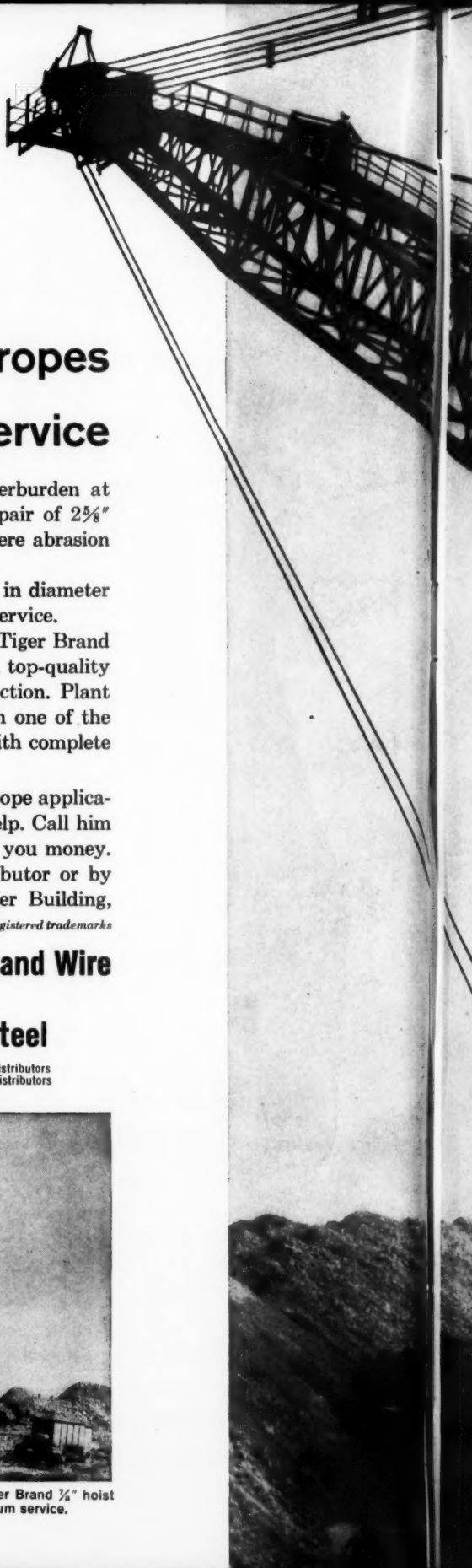
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Blast hole drill rigged with USS Tiger Brand ¾" hoist line and ¼" pull-down line for maximum service.

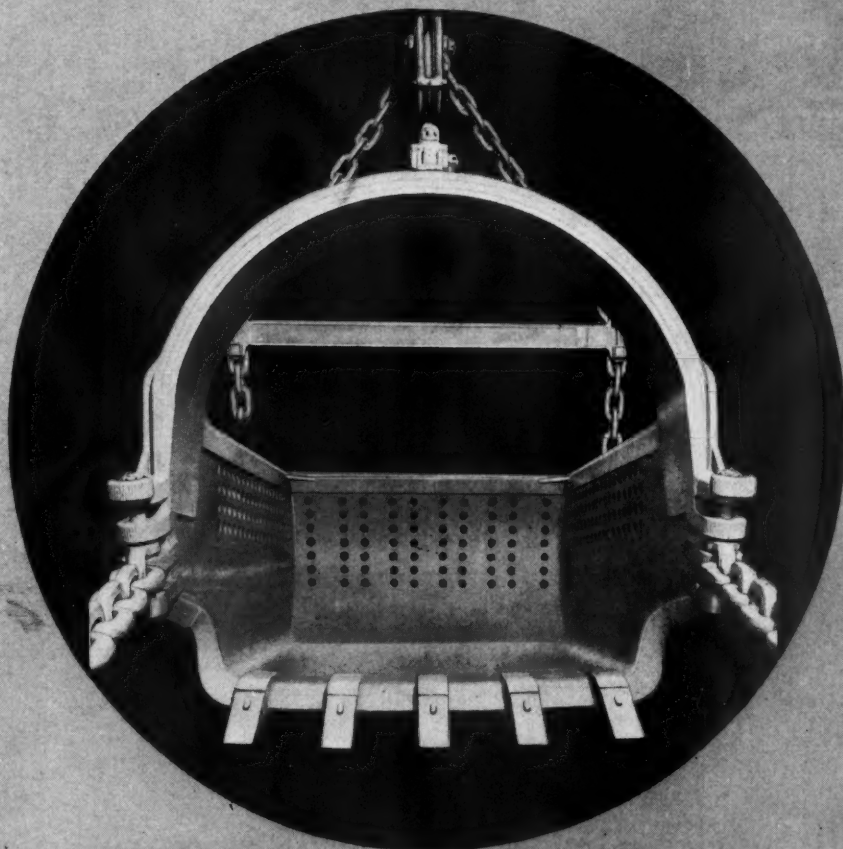




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3 to 40, Cubic Yards With or Without Perforations

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A BELT IS IN
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550 feet per minute is normal for
SCANDURA on this rope conveyor

**National Mine
Service Company**

Koppers Building  Pittsburgh 19, Pa.

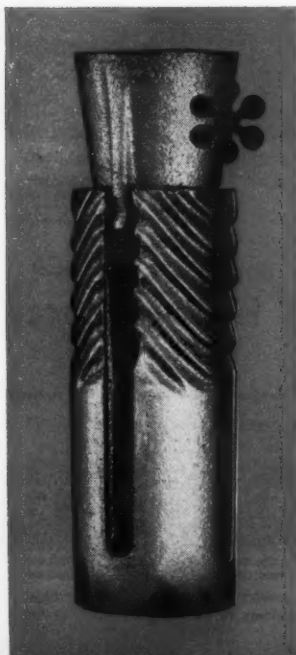
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GOES UP FAST AND STAYS PUT. When the bolt is shoved up the hole, the expansion unit holds the bolt in place until it's tightened . . . no need to have hands exposed to injury during wrenching.

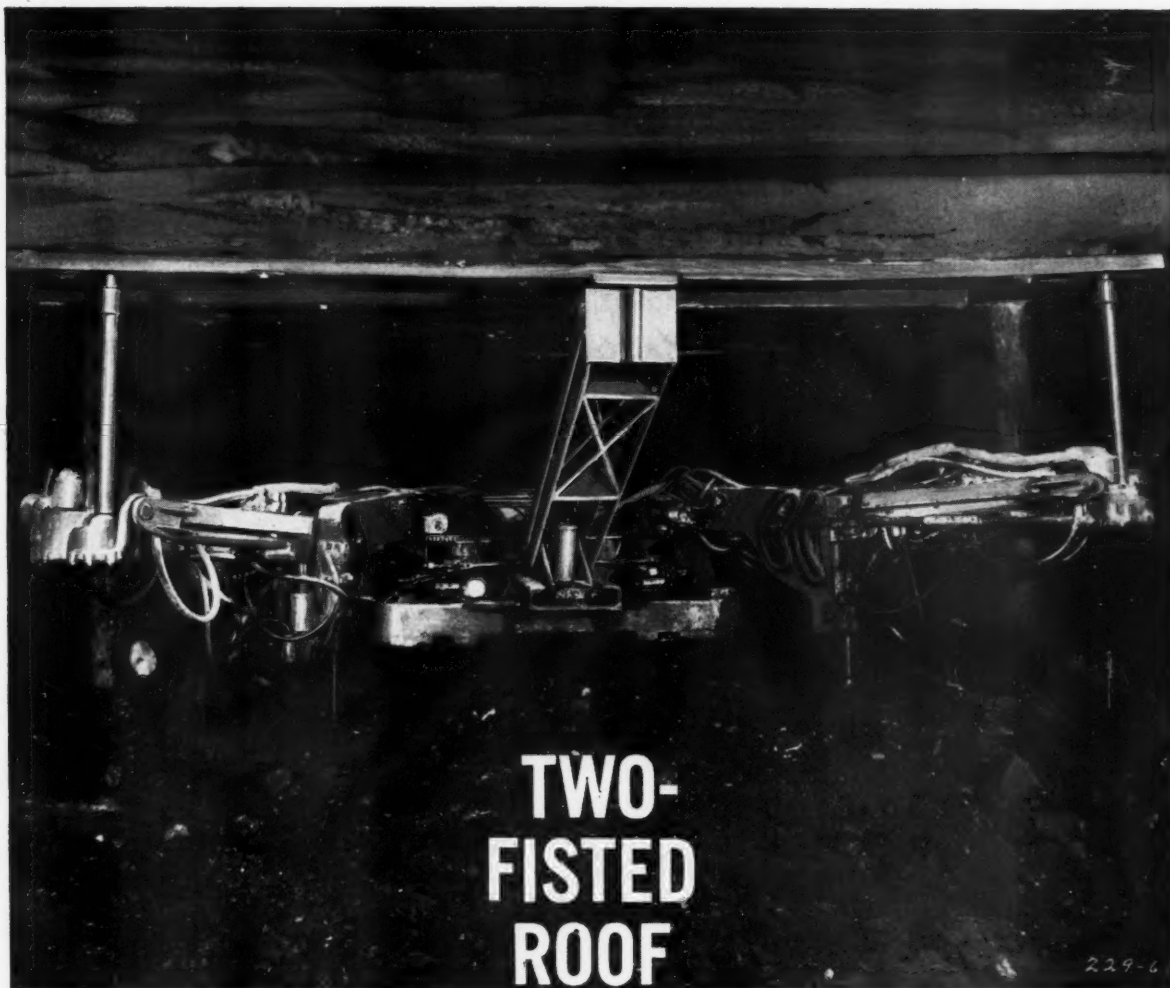
GREATER STRENGTH IN HARD TOP . . . BETTER "PURCHASE" IN YIELDING TOP . . . because the expansion pressures are spread evenly over the four shell fingers to make the best use of the entire unit's strength. These are the reasons for the O-B Expansion Unit's popularity with mining men. It is easy to understand why more mine roof is supported with O-B Shells and Plugs than with any other kind.

For further information and prices, see your local O-B sales-engineer or write us now. OHIO BRASS COMPANY, MANSFIELD, OHIO. Canadian Ohio Brass Company, Ltd., Niagara Falls, Ontario.

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The double drilling arms on the power-packed Jeffrey 56-RDR2 Roof Drill increase production, slash overall bolting time. Each arm swings 80° from the forward position to cover a 24 ft. drilling range. The drill goes where you want it—when you want it. A hydraulically-operated timber-setter is also available for this machine. It provides a lift up to 7' 2½" above the floor. Makes timber-setting a breeze—cuts your costs on this time-consuming operation too! The 56-RDR2 includes

hydraulic tramming on the two front wheels, hydraulic stick-steering for the two rear wheels and a hydraulically-driven automatic spooling cable reel.

The Jeffrey 56-RDR2 machine is available for 250 or 500 volts DC, or 440 volts, 3-phase, 60-cycle AC. A single-arm drilling machine can be supplied for the same voltages.

For full information write The Jeffrey Manufacturing Company, 958 North Fourth Street, Columbus 16, Ohio.

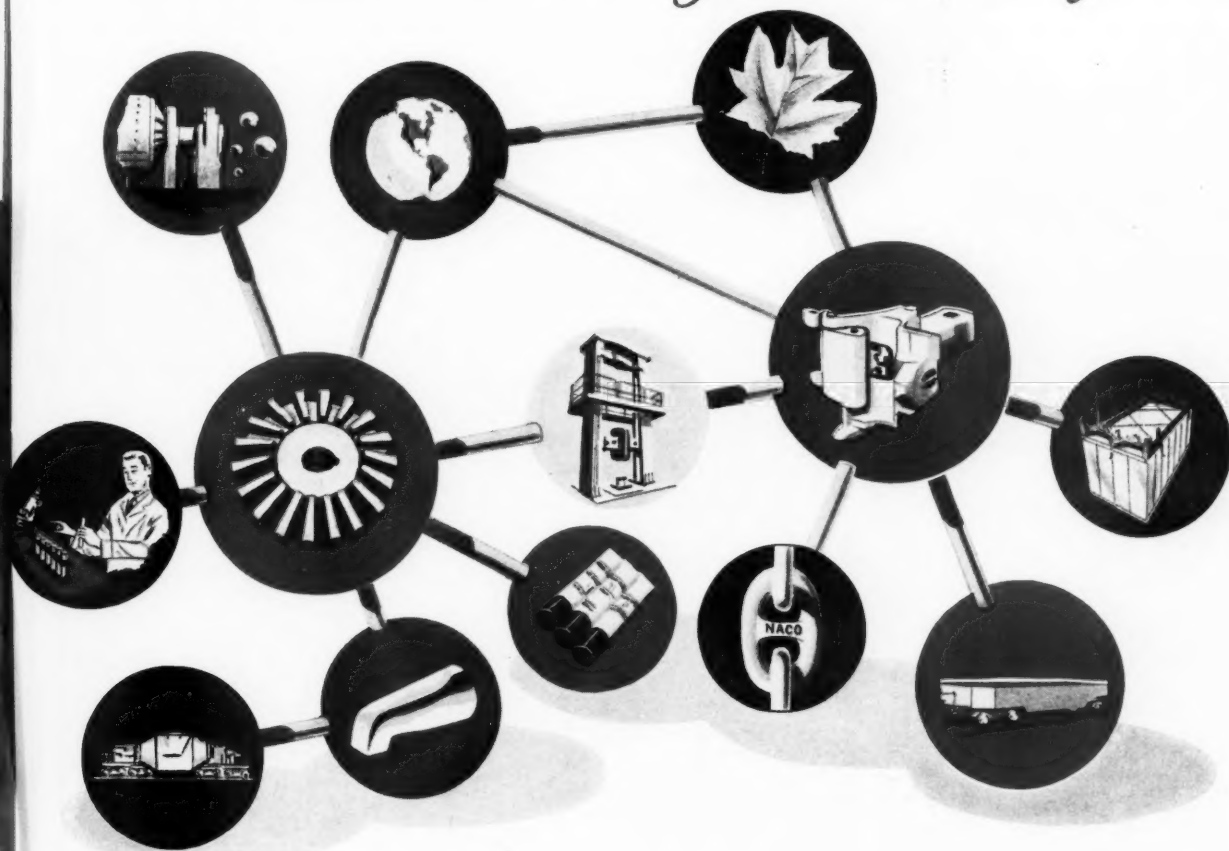
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We changed our name to
National Castings Company



We recently changed our name — from National Malleable and Steel Castings Company to National Castings Company — for these major reasons:

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Increased Scope and Depth of services on both a national and international scale.

We feel, too, that our new, briefer name — National Castings Company — will be more readily remembered. It will probably profit you to remember National Castings Company if your business can use any of these National products or services.

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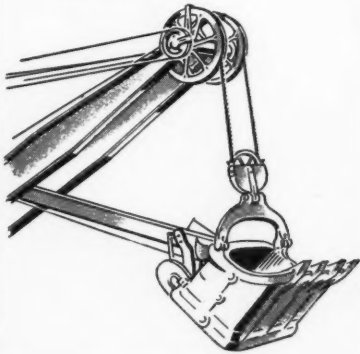
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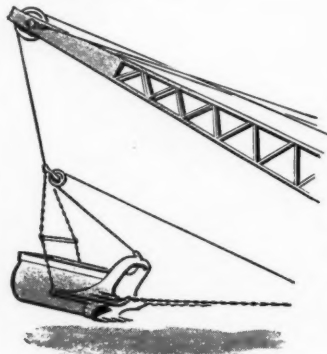
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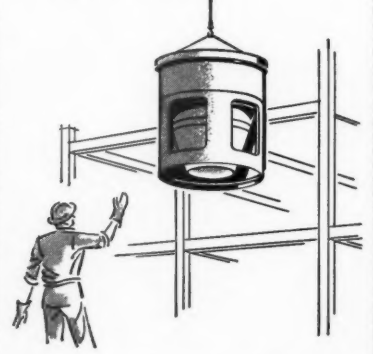
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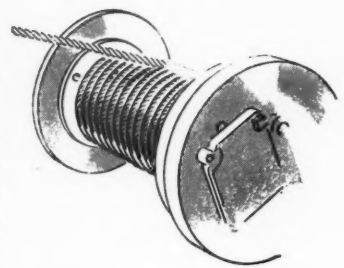
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Model 26 is the ideal centrifuge where space or head room is limited, where production is less than 20 tph and where trouble and down-time free, economical and continuous operation are desired.

The CMI Model 26 is the smallest and most compact centrifugal dryer in the CMI line of dryers in operation in hundreds of installations in leading industries throughout the world.

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... years ahead engineering gives fast, easy access to major components to cut repair and replacement labor time. Compared with a competitive crawler of the same class, the C-6 saves 7 hours on a radiator replacement, 5 hours on a drive sprocket, 6 hours for an engine change, 17 hours on recoil system replacement. Every hour cut from downtime means more productivity and lower operating cost.

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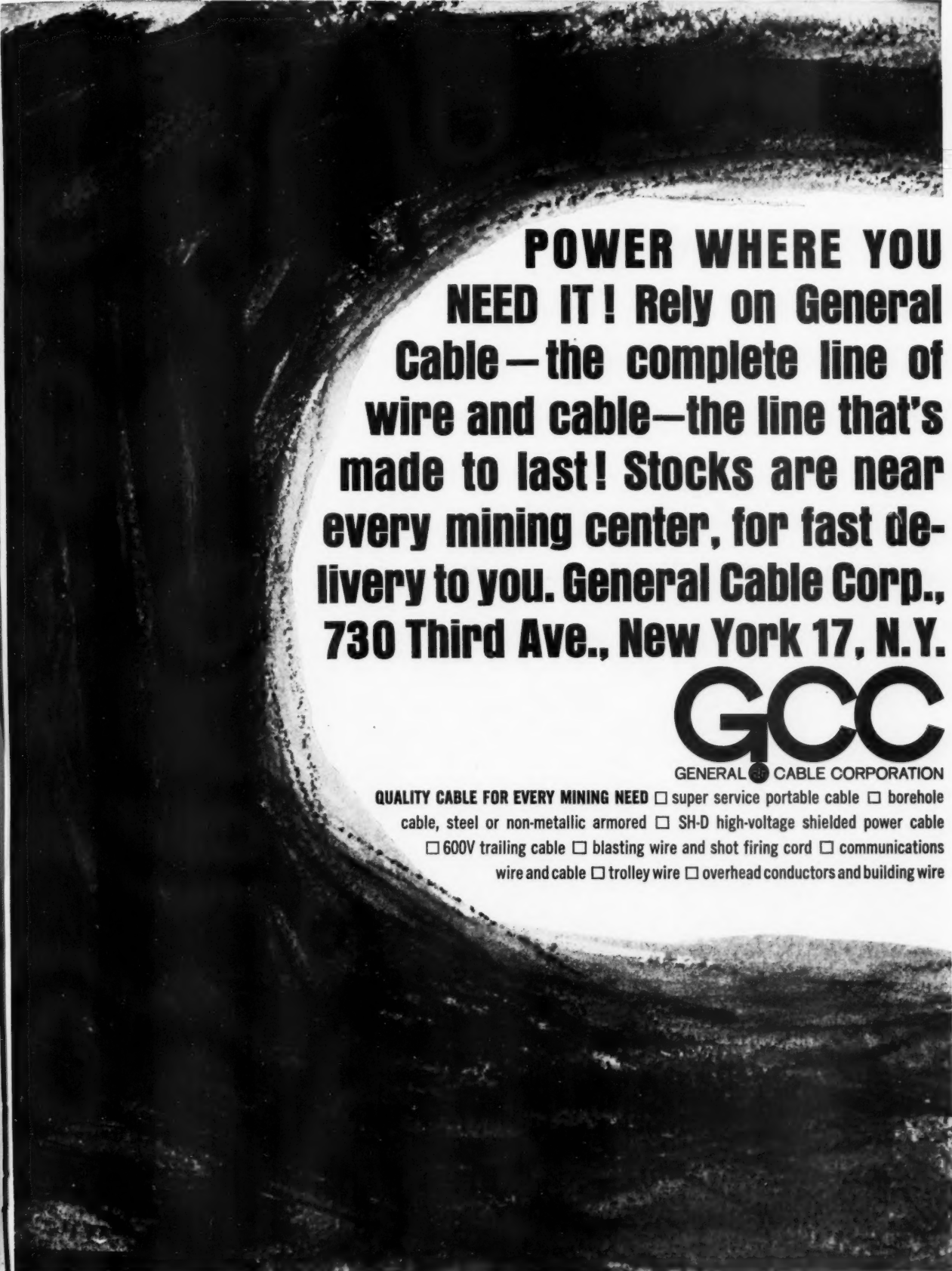
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For primary distribution to high side of transformer: Anaconda SH-D cable. Conductors are insulated with Anaconda AB butyl for improved resistance to heat, water, ozone, aging and compression cutting. Anaconda designed rubber-cores cushion the ground wires, help prevent breaks from kinks and runovers. Exceptionally tough, abrasion-resistant neoprene jacket.

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For A-C Shuttlecars: Anaconda 3/C Flat Type G-600-V Shuttle Car Cable. Flat

construction assures maximum crush resistance and easy reeling. Shaped insulation minimizes mechanical damage because phase and grounding conductors can't shift in use. Power and ground conductors specially engineered to resist bending and flexing fatigue. Color-coded neoprene insulation and neoprene jacket are compounded for toughness, heat stability and crush-resistance. Rubber-coated nylon breaker strips provide extra protection against phase-to-phase

shorts. Nylon seine-twine reinforcement gives high tensile strength.

For high-voltage distribution: Anaconda 3/C 5-Kv Mine Power Cable with Ground Check. Anaconda AB butyl insulation meets or exceeds all industry standards. Anaconda's specially blended AB butyl insulation also gives superior ozone resistance, low mechanical moisture absorption, stable power factor under daily load cycles, greater heat dissipation, and superior aging characteristics. Strand shielding provides uniform stress distribution. Neoprene jacket resists abrasion, oil, grease, mine water and alkalis. Recommended for 90C maximum conductor temperature up to 5000 V; 85C maximum at higher voltages.

For further information on any of these cables, or any other type of mining cable, contact Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York, Department EFL-1-MCJ

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This is
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5 products plus American Oil service help this mine run smoothly



Mr. French Richards of the Pitfair Coal Company watches as American's Bob Chrisman checks temperature of conveyor belt lubricant.



By R. R. (Bob) Chrisman

About the Author.

Bob Chrisman is a specialist in solving the lubricating problems of mining. Holding a degree in mechanical engineering from West Virginia University, Bob has served commercial customers for 27 years. He has been with AMERICAN OIL COMPANY since 1941.

☆ ☆ ☆

The Pitfair Coal Company operation at Clarksburg, West Virginia, is a "slope" mine, tunneled deeply into the side of a hilly ridge. Throughout the mine itself and at the company's tipple, all equipment—cutting machines, conveyors, truck and loading devices

—are lubricated by American Oil products especially developed for each type of service. The consistent trouble-free performance is one reason why Pitfair has relied on American Oil 100% since 1955.

Another reason is service. Whenever lubrication problems arise, the Pitfair people look to American Oil for helpful technical assistance, and they get it. For example, we recently helped work out a special system for handling the coal spraying operation.

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Yieldable Arches "give" to stabilize roof

Where conditions underground are unstable, Bethlehem's Yieldable Arch is often the best answer for dependable roof support. Utilizing the old technique of letting the enemy beat himself, the Arch yields gradually instead of steadfastly resisting, so that the overburden can settle into a natural arch of its own.

As long as pressures are excessive, the Yieldable Arch will con-

tinue to "give." As soon as stability is reached, the Arch holds the line.

A Yieldable Arch Set consists of curved U-shaped sections nested together and overlapped enough to permit clamping with husky U-bolt clamps. The clamps control the tightness in the joint, and permit yielding when the forces exceed the load for which the joint was intended. Each Arch set is

connected to adjoining sets by means of horizontal struts, which add lateral rigidity to the structure.

Besides increasing mine safety, the Yieldable Arch offers high salvageability, and usually pays for itself within its first year of service. A Bethlehem engineer would like to discuss the Yieldable Arch with you. You can reach him through the nearest Bethlehem office.

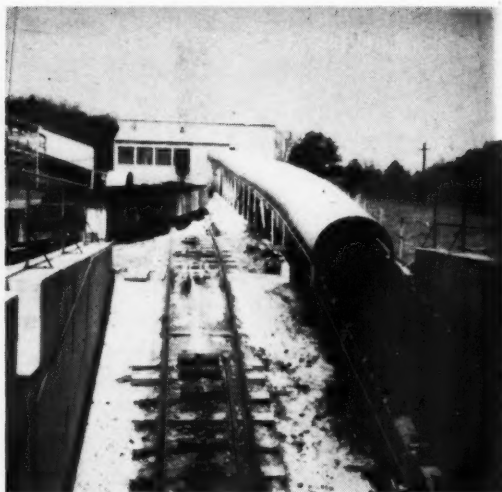


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Economic studies showed a 16° 1450-ft slope to be cheaper than vertical hoisting at a depth of 400 ft

Segco No. 1 Mine

By JAMES E. BROWN, JR.
Manager of Coal Mine Operations
Southern Electric Generating Co.

and

G. C. DYAR
Vice President—Mining Operations
Alabama By-Products Corp.

SEGCO No. 1 mine is located in the Warrior Basin of the Alabama Coal Field in Walker County. It was opened to the Mary Lee Seam in 1959.

This new deep mine was opened to supply 1,500,000 tons per year of low cost fuel to the Segco No. 1 Steam Plant of the Southern Electric Generating Co. The coal is shipped 120 miles by rail to the plant.

Southern Electric Generating Co. was formed to supply the ever increasing market for electricity in Alabama and Georgia and is a member of the Southern Co. System and equally owned by the Georgia and Alabama

Power Companies. The Segco No. 1 steam plant will have an output of 1,000,000 kw that will be sold equally to the parent companies.

Coal 54 in. in Thickness Being Mined

The Mary Lee Seam averages 54 in. in thickness in this area. Under an average cover of 500 ft it has a six-in. rock parting 12 in. from the seam bottom. The roof and floor are firm except in areas near faults where the top is cut by slips and the bottom softened by water. The seam pitches about 1½ percent to the southeast with many heavy irregular grades.

Faults, many of which have a large displacement, are characteristic of the area.

Seam height, elevation and quality were determined from records of adjacent mines formerly operated in the same seam. These records were checked by 28 diamond drill holes located over the mine property. Cores were analyzed to check quality and studied to determine seam top and bottom conditions.

The location and displacement of faults were established from records of adjacent mines in the same seam, upper seams mined on the property, outcrop of upper seams and by surface examination.

The preliminary capital cost estimate was made from experience gained in the construction of another mine of similar size, taking into consideration the differences in mining and preparation problems. The preliminary operating cost estimate was made from previous experience, taking into consideration the improvements in equipment and technology weighed against the differences in mining conditions.

Final cost estimate was made after a plan for underground development was prepared. In preparing this plan, consideration was given to productivity, recovery, fault location, ventilation, haulage, roof control and drainage.

After the plan was prepared an over-all general plan for the construction and development of the mine was completed. This plan included specifications, set out all



Underground coal haulage is provided by 42-in. rope belt conveyors operating at 620 fpm. The supply track is 42-in. gauge using 90-lb steel

of the Southern Electric Generating Co.

Thorough planning led to a final construction cost of approximately \$7.00 per ton of annual production for this 1,500,000 ton per year coal mine

phases of construction, listed in detail all equipment and facilities, including construction, development and equipment delivery schedules, together with a detailed cost estimate of constructing and developing the mine.

Final operating cost estimate was prepared from the master plan for underground development and the over-all general plan.

Acquiring of funds for construction and development was tied closely to the prepared schedules to keep interest charges at a minimum.

The mine was financed and paid for by Southern Electric Generating Co.

The final cost of mine was slightly under estimated cost and came to approximately seven dollars per ton of annual production.

Mine Designed for Annual Output of 1,500,000 Tons

The annual tonnage of 1,500,000 tons per year was determined by power plant needs and economical rate of extraction of the coal reserves available in the property.

Segco No. 1 mine is located near the center of the mine property, on a paved road, near adequate water supply where surface topography was very favorable for the construction of mine facilities. The mine is connected to Southern Railway by $1\frac{1}{2}$ miles of spur track.

Connections to the surface include a 1450 ft 16 degree belt and supply slope equipped with a 42-in. rigid frame belt conveyor 1660 ft long op-

erating at 600 fpm and a 42-in. gauge supply track using 90-lb steel.

The slope belt drive and slope hoist are located in the same building which also serves as a transfer point for coal going to the raw coal storage pile and for mine rock traveling to the rock bin.

A second connection is an intake air and manway shaft 20 ft in diameter and 400 ft deep. The entire shaft was gunited and is equipped with a 32-passenger automatic elevator.

The third connection is an exhaust air shaft 20 ft in diameter. Two 10-ft diameter axial flow fans are con-

nected to this shaft; one is powered by a 400-hp 440-volt electric motor, the other by a 400-hp diesel engine. This dual fan installation is fully automatic, changing from one to the other without attention. Fan size and horsepower were selected after a ventilation survey was made of the underground projection map, using air quantities sufficient to dilute and render harmless the anticipated methane liberation.

The 16 degree slope was selected because conveyor belt haulage at a 400 ft depth was cheaper than hoisting; also, it provided easy and economical access for large heavy mod-

Safe ventilation, always a must, is gained by the use of two 10-ft diam axial flow fans (one is a standby) set to exhaust through a 20-ft diam 400-ft deep shaft



ern mine equipment and for the large volume of supplies required in a modern mine. Crushing was established at the slope bottom to minimize wear and to prevent damage to the expensive slope belt by large pieces of rock and coal.

An intake air and manway shaft was established to provide a second travelable access to the mine as required by mine law and to accommodate the large volume of air required in this gassy mine without creating excessive air velocities on the slope and at the slope bottom.

The exhaust air shaft was provided to take care of the large volume of air with minimum power.

Surface facilities are provided as follows:

1. A 73 by 112 ft bath and lamp house located at the intake and manway elevator shaft. This building also houses the offices of the underground supervisors and of the safety department.

2. A 40 by 150 ft supply house located at the intake and manway shaft and connected by covered passageway to the mine shop.

3. A 40 by 180 ft mine maintenance shop. The total area of the shop is served by an overhead crane. Shop equipment includes lathe, milling machine, shaper, rotary drill press, metal cutting band saw, bit sharpener, pipe and bolt machine and full complement of tools, meters and gauges.

4. A 26 by 48 ft truck and tractor maintenance building located near main shop.

5. A 13 by 19 ft powder magazine and a 6 by 8 ft cap magazine located in an isolated position and in accordance with established standards.

6. A 25 by 78 ft building provides extra storage for underground cables and power line accessories.

7. The main office houses the superintendent, assistant superintendent, accounting department, engineering department, main telephone switchboard, and has a large meeting room. This office is located near the county road at the plant entrance.

8. A 24 by 60 ft project engineer's office.

9. Five brick residences are located on a hill above the mine.

10. A 12-kva main substation is located on a small hill in center of mine facilities.

11. A 3,725,000 gal earth reservoir located on a hill above mine supplies water for preparation plant, fire protection and underground spray water.

12. Two 1000 gpm vertical turbine pumps supply water to the reservoir from a backwater creek.

13. A 50 gpm filter plant supplies potable water for bathhouse, residences and offices.

14. An oil house and other storage facilities for heavy supplies are located at supply yard near slope entrance.

Preparation Plant has Capacity of 750 TPH

From the slope belt transfer house a 42-in. stacker conveyor belt stores

The simplicity of the 750-tph preparation plant was dictated by sink and float analyses of Mary Lee coal and boiler fuel requirements.



raw coal in a 12,000 ton pile over a belt tunnel.

From this same transfer point a 30-in. conveyor belt takes mine rock to a 75-ton rock bin.

In the belt tunnel four vibrating feeders put coal from the raw coal stockpile onto a 36-in. conveyor belt that feeds the preparation plant.

The 750 tph capacity preparation plant includes a Baum type jig, four dewatering screens, one belt conveyor, a drag settling tank, a thickener, attendant blower and pumps and a railroad car hoist.

In the plant, coal from the jig is dewatered and separated on two double-deck 6 by 16 ft vibrating screens. The plus 1/4 in. goes directly to railroad loading belt and 1/4 in. by 0 to a 16 by 63 ft. drag settling tank. The settling tank drag conveyor conveys the coal to two 6 ft by 16 ft by 1/2 millimeter vibrating dewatering screens. Coal from these screens goes directly to railroad car loading belt. The underflow from the thickener is also dewatered on these screens. Underflow from these 1/2-millimeter screens returns to drag settling tank. Most of the overflow from drag settling tank is recycled to the jig with a part of the overflow going to the 90 ft diameter thickener. Most of the thickened overflow returns to jig circulation with a part going to plant bleed. Plant bleed is pumped to settling ponds.

Jig reject is elevated to a rock bin and is hauled by two 27-ton capacity diesel dump trucks to the refuse area.

A 100-hp hoist connected by 1 3/4-in. cable to barney cars handles the entire train of sixty-five 100-ton capacity aluminum railroad cars on the two loading tracks.

The water drains through holes drilled in these cars to reduce the coal to an acceptable moisture during its 120-mile journey to the generating plant.

Preparation plant simplicity was dictated by the sink and float analyses of the Mary Lee coal and specification of the fuel required for the generating plant boilers as set forth by the boiler manufacturers.

At the slope bottom a 200-ton steel surge bin is provided to store coal from the underground conveyor belt haulage. Coal is fed from this bin by a 1000 tph vibrating grizzly feeder. The 3 in. by 0 coal is placed directly on the slope belt. The plus three in. goes to a 30 by 60-in. crusher, and then is placed on the slope belt on a cushion of fine coal. Coal dust in this area is controlled by high pressure fog nozzles.

An electromagnet, with traveling belt to discharge the collected iron, is installed over the incoming conveyor belt to pick up tramp iron ahead of the slope belt.

Coal Haulage is by Belt Conveyors

Forty-two in. by 4000 ft rope belt conveyors, operating at 620 fpm, are used for coal haulage on main primary and secondary entries. The conveyors are powered by two 125-hp a-c motors. Belt take up is by horizontal pneumatic cylinder.

Thirty-six in. by 2000-ft rope belt conveyors operating at 365 fpm are used to transport coal from room entries. Each conveyor is powered by a 60-hp a-c motor. Belt take up is by horizontal hydraulic cylinder.

All conveyors are advanced and recovered in 250 ft lengths. Coal is



Adequate roof control, a vital part of the safety program, is maintained by the use of expansion shell roof bolts. In permanent air ways a 2-in. by 8-in. by 24-in. creosoted cap piece is used under the washer of all bolts



Conventional mining equipment proved the "best choice" after two trials with ripper type miners

placed on all conveyors by surge hoppers. These hoppers are used to insure rapid shuttle car discharge, to protect conveyor belt from damage caused by shuttle cars discharging directly onto belt and to prevent overloading with its attendant spillage.

All belt transfer points are equipped with water sprays, spillage, belt fray protective devices and interlocked with centrifugal switches.

All conveyors are equipped with USBM approved fire resistant belting to provide maximum protection against belt fires and to eliminate brattice cost of providing a separate split for belt installations.

Conveyor belt haulage was selected because of anticipated frequent heavy irregular grades (up to 19 degrees), the location of the mine near the center of the mine property and to facilitate the crossing of the faults characteristic of this area.

Rope belt was selected because of the ease and cheapness of extending and retreating the conveyor, less spillage, longer life of conveyor belting, reduced capital investment and flexibility.

Men and supplies are transported on a 42-in. gauge 60-lb track paralleling all 42-in. conveyors. The 42-in. conveyor, 42-in. track and 4.1 kv power cables are placed in the same entry. Rock is brushed in this one entry to a clearance height of five ft.

Portal busses are used to haul men from the elevator shaft bottom to the room entry turnouts; they then ride on the 36-in. belts to and from the working face.

Supplies are handled in special supply cars pulled by d-c locomotives

to the entry turnouts and then transported to the working face by battery powered tractors and trailers.

Track jeeps transport supervisors and maintenance men. Special rubber-tired motorized cable reel and belt reel trailers are used to handle cables and conveyor belt.

Face Equipment Uses A-C Power

A-c power is used throughout the mine operation except on inside supply track haulage.

Surface distribution is at 12 kv reduced to 440-220-110 volts for surface facilities. At 1000 kva surface transformer stations 12 kv is reduced to 4.1 kv for underground distribution. The ground for all underground a-c equipment is initiated at these stations through a grounding resistor.

Portable 4.1 kv breakers with visible disconnecting switches are installed at bore hole bottom and 4.1 kv portable oil circuit breakers are used at each entry turnout for section isolation.

Power centers of 300 or 500 kva rating are located near the working areas to reduce the voltage to 440 for face equipment use. From the power centers 440 volts is carried to two face distribution boxes. Face equipment trailing cables are attached to these permissible breaker equipped distribution boxes.

Power centers of 225 and 112½ kva capacity are provided for belt drives, pumps and other auxiliary equipment.

Molded type vulcanized connectors are used to connect all 4.1 kv and 440 volt cables. Gang boxes are used

to attach all 4.1-kv side circuits to the main 4.1-kv cables. All 4.1-kv cable is suspended on messenger wire supported by roof bolts and insulators.

Two 150-kw silicon rectifiers, 4.1 kv—300 vdc furnish power for underground supply track haulage.

A-c power was chosen because of lower initial cost, lower maintenance cost, less down time on face equipment and for safety.

Equipment to complete each unit of face equipment included:

- 1—Universal rubber-tired cutting machine with nine ft cutter bar.
- 2—Hydraulic hand-held coal drills.
- 1—Loading machine rated at 18 tpm.
- 3—Shuttle cars of five-ton capacity.
- 1—Rubber tired mobile roof bolting machine with single drilling boom.
- 1—Four-wheel drive rubber-tired battery tractor with two trailers.
- 1—Battery charger.
- 1—Rubber-tired electrician's trailer.
- 2—Surge hoppers.
- 1—Low pressure rock duster.

Conventional equipment was selected for all production units after two trials of ripper type continuous miners proved disappointing tonnage wise because of the hardness of the coal and the six-in. rock parting.

The highest capacity equipment available to fit a minimum seam height of 46 in. was selected. In order to insure minimum face down time and to accommodate high capacity loading equipment, three shuttle cars per unit are used.

After underground development began, unanticipated soft bottom was encountered in some areas of the mine. To operate in these areas, the cutting machines on the last three production units purchased were equipped with four-wheel drives.

In this soft bottom, it was found difficult to maneuver the short wheel base, narrow gauge roof bolting machines. To operate in the soft bottom areas two large roof bolting machines, each equipped with two roof drilling booms and one machine with one roof drilling boom and one horizontal boom for coal and rock drilling were purchased instead of the original single drilling boom, small roof bolting machines.

In addition to these rock drills, stoppers and jack hammers with their attendant air compressors are provided for rock drilling in overcast and belt header excavation.

Plastic Sheeting Used on Temporary Brattices

The exhaust system of ventilation is used with each working entry on a separate air split. No haulage way doors are found in the mine. Workings are sealed after coal mining is finished.

To control ventilation permanent brattices are constructed of special concrete blocks sealed with "mine seal." Permanent overcast walls are constructed of special concrete blocks with light aggregate slabs supported by steel beams forming the overcast bottoms. Portable temporary overcasts are constructed of corrugated metal, and are designed for ease of erection and transportation. Temporary brattices are of wood sealed with polyethylene sheeting. The face ventilation is accomplished by the use of two double drop curtains in cross cuts where shuttle cars travel and by line curtains of brattice cloth from the last cross cut to the face.

Mine roof is controlled by the use of expansion shell type roof bolts placed by rotary drills mounted on roof bolting machines, and by posting and timbering. In permanent air ways a 2 in. by 8 in. by 24 in. creosoted cap piece is used under the washer on all roof bolts, and creosoted posts are set where the top indicates that they are needed. In bad ground, steel and creosoted wood sets are used to support the roof. Untreated posts are used for temporary roof support in the face area if necessary.

Coal dust is controlled by the use of water on cutter bars of mining machines, sprays on loading machines and at all belt transfer points. Water is also used in all rock drilling. Four-in. spray water lines parallel all 42-in. belts. From these lines two-in. lines extend to working areas where hose is used to carry water to the face equipment. Spray water is furnished from the surface reservoir.

Coal dust is allayed by the use of rock dust. Thirty-five tons of rock dust is distributed each working day. Low pressure mobile rock dusters distribute rock dust in the face areas. A track mounted high pressure rock duster with attendant hose is used to dust entries and airways.

Mine water is gathered by piston pumps and piped to main sumps where it is pumped to the surface through bore holes by automatic centrifugal pumps or by surface driven vertical turbine deep well pumps.

Communication inside and outside the mine is by trolley phone and telephone. Trolley phones are installed near the working face in all working sections, on mine jeeps, on the man elevator and at all locations where instant communication is necessary. Fire extinguishers are located in all working areas, at belt transfer points, pumping stations, electric motor locations, and all places where a fire could originate inside and outside the mine. For protection against the possibility of a fire beyond the scope of the smaller extinguishers, dry chemical in protective cans to be distributed by low pressure rock dusters is stored near each entry turnout.

One extra section with complete complement of mining equipment is kept in readiness. This maintains a continuity of production while other sections are idled one at a time for

preventative maintenance or belt extensions on the operating shifts. Major underground maintenance and belt extension is done on the third shift. For the maintenance cycle one extra machine of each type was purchased. This allows complete shop overhaul of equipment when total operating hours, tonnage handled, and down time indicate the necessity of reconditioning. All equipment is overhauled in the surface maintenance shop.

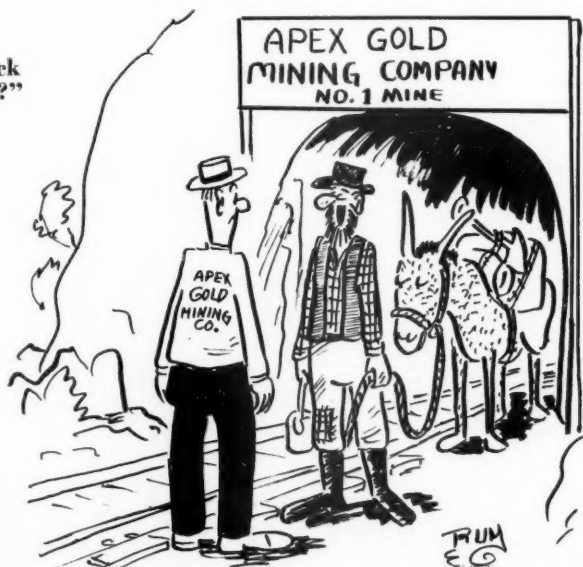
Repair and replacement parts and necessary hand tools for repairs at the face are kept in the electricians' carts located near the face areas.

A room and pillar system of mining is used with 16 place ways on main entries, 11 place ways on secondary entries and five place ways on room entries. All headings and airways are 25 ft wide. Rooms are 35 ft wide and 260 ft deep.

This mine operates two production shifts per day, with the third shift used for major maintenance, belt extensions, rock dusting and other dead-work.

Eight conventional sections, operating two shifts per day, produce 3667 tpd of raw coal. Seam reject is 25 percent. Each operating day 6500 tons of washed coal are shipped. Production crews consist of 12 men, inclusive of an electrician and section foreman. The total number of employees on the payroll at this mine is 340.

"Yep, struck gold. Why?"



Program for maintenance of mobile equipment

By HOWARD HANKS, JR.
Operations Engineer
Marquette Cement Manufacturing Co.

Can your maintenance efforts be improved? The answer is obviously yes. Do you have a program for maintenance? Anyone who operates mobile equipment must maintain the equipment. But, it doesn't necessarily follow that the maintenance will be programmed. The program must be broad enough to cover the entire maintenance spectrum. To program maintenance is to systemize and evaluate the maintenance effort. The objective is control of maintenance and cost reduction

FIG. 1. MAINTENANCE PROGRAM EVALUATION CHECK LIST

On each of the following, enter a score which to the best of your knowledge reflects the contribution of this item as you believe it should to your maintenance effort. (Use fractions if you desire.)

SCORE

- 3.—If you consider that your present utilization of this item to benefit your maintenance program is satisfactory.
- 2.—If you consider that your present utilization of this item to benefit your maintenance program is in need of improvement.
- 1.—If you consider that your present utilization of this item to benefit your maintenance program needs a great deal of improvement.
- 0.—If you consider that your present utilization of this item to benefit your maintenance program is nil.

1. MAINTENANCE ACCOUNTING

- A. Maintenance Cost Reports (By Equipment).
- B. Other Cost Reports.
- C. Equipment Cost Comparisons.
- D. Replacement Program based on Maintenance Costs.
- E. Machinery and Equipment Properly Numbered or Coded to Permit a Mechanic Identification.
- F. Overtime Reports.
- G. Ratio of Preventive Maintenance to Breakdown Maintenance.
- H. Ratio of Downtime to Operation Time.
- TOTAL $\times 100 \div 24 =$ %

2. PREVENTIVE AND BREAKDOWN MAINTENANCE

- A. Equipment Records.
- B. Scheduled Inspections.
- C. Inspection Check Lists.
- D. Work Orders.
- E. Lubrication Routes and Instructions.
- F. Spare Parts Program.
- G. Exchange Assemblies.
- H. Rebuilding High Wear Items.
- TOTAL $\times 100 \div 24 =$ %

3. CORRECTIVE MAINTENANCE

- A. Material Changes.
- B. Design Changes.

- C. Exchange and Publication of Improvements.
- D. Problem Recognition.
- E. Encouragement and Recognition of Employee Suggestions.
- F. Plant Engineering Participation.
- G. Use of Manufacturers Field Representatives.
- TOTAL $\times 100 \div 21 =$ %

4. TRAINING

- A. Use of Manufacturers Field Representatives.
- B. Use of Dealer Facilities and Personnel.
- C. Use of Manufacturers Parts Books, Operating and Repair Manuals.
- D. Skill Development (Specializing)
- E. Correspondence Courses.
- F. Informal Group Classes.
- G. Equipment Operator Training.
- H. Supervisor Training.
- TOTAL $\times 100 \div 24 =$ %

5. PRODUCTIVITY

- A. Work Sampling.
- B. Mechanized Tools and Equipment, Labor Saving Devices.
- C. Adequate Transportation Facilities.
- D. Ability Ratings.
- E. Time Study.
- F. Force Reduction.
- G. Job Standardization.
- TOTAL $\times 100 \div 21 =$ %

6. MANAGEMENT

- A. Communications.
- B. Job Planning.
- C. Job Scheduling.
- D. Morale.
- E. Labor Relations.
- F. Participation and Enthusiasm for Organized Maintenance.
- G. Equipment Service. (Minimize equipment wear and tear with smooth, dust free roads, etc.)
- TOTAL $\times 100 \div 21 =$ %

1. — Total
2. — Total
3. — Total
4. — Total
5. — Total
6. — Total
- GRAND TOTAL $\times 100 \div 135 =$ %

MODERN technology and competition have made the maintenance problem more difficult. Closer design tolerances and allowances, higher speeds, greater loads, equipment complexities, coupled with the demands for greater production, less downtime, and reduced budgets make this problem a real challenge.

Too Little Time and Effort Devoted to Problem

The enlightened manager is aware of the magnitude of this problem and devotes some of his effort to its solution. Every operator recognizes the existence of the problem, but too few devote the time, talent, and energy needed to bring the maintenance problem under control. We're too busy with production quotas and deadlines, sales, budgets, taxes, labor contracts, wages and a host of other things. Furthermore, old Joe, he'll keep it running—he always has and, no doubt, he always will.

The objective here is to outline a program for attacking the problem, dealing with basics rather than detailing requirements of a program. A point that can't be over-emphasized is the need to examine the basic program, determine company needs and then take action.

To define what is meant by a basic maintenance program is to set forth its components. This is to say that to cure a problem, it is first necessary to recognize what the problem is. Figure 1 arbitrarily divides a complete maintenance program into six categories: (1) maintenance accounting, (2) preventive and breakdown maintenance, (3) corrective maintenance, (4) training, (5) productivity, and (6) management. These categories overlap and vary in importance with a company's particular needs, which must be evaluated by careful consid-

eration of its present program. Scoring the checklist in figure 1 will reveal a program's weaknesses.

Maintenance accounting is a cost account of labor and parts necessary to maintain a unit of equipment in a satisfactory operating condition. These costs must be charged and posted for accumulation against a unit of equipment. To start with, charges should be accumulated against only major equipment, and those not chargeable to a major unit should be charged to a miscellaneous account. If the miscellaneous account grows too fast—pull out the high cost items and establish accounts for them.

Labor and Material Costs Need Regular Review

The mechanic accounts for his day's activities by reporting hours spent on various equipment. His report should be a written entry on a simple form. His foreman verifies this report and distributes his men's time against the various equipment. The storeroom distribution of materials used must also charge materials and parts issued against the same equipment accounts. On cards

hourly wage rate—revising up or down from time to time as necessary to keep these labor costs in line with labor costs accumulated departmentally.

Since this requires an additional clerical effort resistance may be encountered. It may be passive or hostile. Overcoming resistance requires a combination of judgment, sincerity, tact, patience, and forcefulness.

It was mentioned that the reports require management review. This needs restating for emphasis. As this history of maintenance costs grows, the true story of expenditures will unfold. Soon it will be learned which equipment should be overhauled or replaced and you are automatically supplied with economic justification. It will be known which equipment is being improperly repaired or main-

to destruction and which to replace at suitable intervals. An example of breakdown maintenance would be replacement of a tire after failure. To replace a tire prior to failure as the result of inspection or prudent estimate of life expectancy is an example of preventive maintenance.

Proper Lubrication Vital to Preventive Maintenance

Proper lubrication is probably the most vital segment of preventive maintenance. Briefly, it means complete coverage, at proper intervals, and the use of clean lubricants in the correct amounts. This is a large order and it is easy to be glib about it. A proper lubrication program is tedious, which is why it is usually ignored, but it will pay off to build a lubrication program from the ground

Fig. 2. The cost of materials and parts issued by the storeroom and labor costs are posted daily on equipment record file cards such as the one shown at left

EQUIPMENT		RECORD	
WHS. NO.	TYPE OR MODEL	WHS. NO.	REPAIR NO.
EQUIP. NO.	DATE OF ACQ.	REPAIR NO.	DATE OF ACQ.
VENDOR	INSTALLATION COST	DATE INSTALLED	LOCATION
EQUIPMENT DESCRIPTION			
MAINTENANCE REQUIREMENTS		ELECTRICAL EQUIPMENT	
INSPECTION REQUIREMENTS		EQUIP. NO.	
		MAKE	
		SERIAL NO.	
		TYPE FRAME	
		VOLTAGE	
		PHASE	
		H.P.	
		G.P.W.	
		DRIVE	
		CIRCUIT	
		METER	
		COST	
LUBRICATION			
LUBE TYPE		LUBE QUANTITY	

such as those in figure 2 are posted the labor hours and material costs. Monthly or quarterly cost reports giving yearly totals to date, by equipment, of maintenance labor and material expenditures gathered from these cards should be issued for management review.

Obviously, reported total expenditures must agree with totals accumulated by any other accounting methods such as indirect departmental repair and maintenance or whatever you choose to call them. Comparison of totals shown on the various cost reports will show up faulty maintenance accounting practices. Comparable costs need not agree to a penny—in fact, at Marquette we post only repair hours and multiply total hours at the end of the month by a weighted

Fig. 3. (right) Use of inspection and lubrication cards is a simple and foolproof way to avoid embarrassing and expensive oversights

EQUIPMENT		RECORD	
WHS. NO.	TYPE OR MODEL	WHS. NO.	REPAIR NO.
EQUIP. NO.	DATE OF ACQ.	REPAIR NO.	DATE OF ACQ.
VENDOR	INSTALLATION COST	DATE INSTALLED	LOCATION
EQUIPMENT DESCRIPTION			
MAINTENANCE REQUIREMENTS		ELECTRICAL EQUIPMENT	
INSPECTION REQUIREMENTS		EQUIP. NO.	
		MAKE	
		SERIAL NO.	
		TYPE FRAME	
		VOLTAGE	
		PHASE	
		H.P.	
		G.P.W.	
		DRIVE	
		CIRCUIT	
		METER	
		COST	
LUBRICATION			
LUBE TYPE		LUBE QUANTITY	

MACHINE NO.		TYPE MACHINE											
		MECHANICAL ELECTRICAL GENERAL SCHEDULE											
TO		ELECTRICAL											
TO		MECHANICAL											
TO		GENERAL											
YEAR		OIL CHANGE AND LUBRICATION SCHEDULE											
TO		MAINTENANCE COST SUMMARY											
YEAR		JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC											
1		LBS											
1		BAT											
1		TOTAL											
2		LBS											
2		BAT											
2		TOTAL											
EQUIP. NO.		DESCRIPTION											
		MONTHLY INSPECTION CONTROL											

tained—which equipment is superior. If this information is put to good use, the cost of this phase of the program is easily justified. This phase can be kept simple, complete, and accurate by enlisting the aid of those involved.

Preventive and breakdown maintenance are perhaps better described as before and after failure-maintenance. There is a place for each. Experience will dictate which equipment to run

up. It requires effort to initiate, and responsible people to actuate. Help on this is available from the lubricant supplier. But the operator shouldn't make the mistake of believing that he has a program simply because he has a handsome lubrication manual from the oil company. The use of inspection and lubrication schedule cards, (see figure 3), though simple, is a foolproof way of avoiding embarrass-

ing and expensive oversights.

Periodic inspection of equipment by a qualified observer can uncover a soon-to-occur breakdown. Inspection frequencies are determined by experience. At Marquette Cement the inspection and lubrication cards are equipped to flag the date of the next lubrication, inspection, or repair. Shrewd judgment is required to make the inspection work load uniform. When an inspection date arrives, a work order is issued stating the scope of the inspection required. The inspector must be qualified to recognize symptoms of imminent failure. A typical inspector's checklist is shown in figure 4. Those permitted to author, approve and review these work orders must be decided. The orders are attached to clip boards in the repair foreman's office by class—Urgent, Preventive, Regular and Incomplete. They provide the foreman with a backlog of job assignments. A complete inspection checklist is also issued at appropriate intervals. When the work orders are complete or the checklist is filled out, they are returned for filing.

The objective in having a preventive maintenance program is to reduce the number of emergency breakdowns, which occur at random and always result in uneven work loads and high maintenance costs. Periods of hard, long, and expensive repairs are followed by periods of relative inactivity.

This phase can be started by programming 15 percent of the repair work effort as preventive maintenance. The percentage is increased in accordance with the department's ability to handle the additional work. Overtime and emergency work load should decrease. If the backlog of work decreases too rapidly, it indicates that the repair department is over-staffed.

Preventive Maintenance Can Be Overdone

The repair department should not overdo inspections or make premature preventive maintenance repairs to keep people busy. With emergency breakdowns reduced, and preventive maintenance jobs to round out an even work load, maintenance and repair manpower requirements will also be reduced.

The optimum ratio of emergency to scheduled repair work can be determined in time by a gradual increase in preventive maintenance as a percentage of the total work load. Efforts to reach 100 percent preventive main-

tenance should, however, be avoided since it ultimately results in wasting materials and manpower. The department should shoot for a 50-50 split, then evaluate its position, deciding whether to retreat or proceed.

To make this determination of preventive maintenance as a percentage of total work load, it is necessary for the foreman to show on his time distribution sheet the number of labor hours spent on preventive maintenance.

Spare parts inventories can be reduced substantially with an effective preventive maintenance program. When it is known that replacement parts will be required because of a scheduled overhaul, the necessary parts can be ordered.

Promote Corrective Maintenance

Corrective maintenance is that part of a program that should appeal to maintenance people the most. It brings out the inventive spirit, and actually, many of the ideas may be patentable. No manufacturer claims to be infallible; he is usually designing for a broad market application and a specific use may show up flaws in the equipment that were never antici-

pated. Furthermore, designers make mistakes just like anyone else. To make alterations in material, size or shape, in an effort to reduce rate of failure, is to engage in corrective maintenance.

Usually, such corrective action is recognized and accomplished at the grass roots of the maintenance organization—by a mechanic and his foreman. The plant engineering group can lend needed assistance to this phase of maintenance.

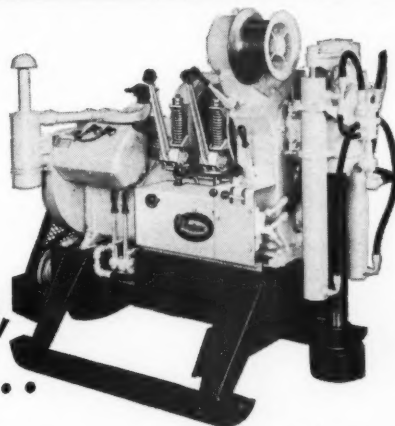
Company wide publicity of contributions by employees go far toward advancing the cause of corrective maintenance.

Cost reduction from an active corrective maintenance program are usually expensive to evaluate. There is some question as to the value of formally evaluating the cost reduction after the improvement. It seems more important to delegate to a qualified person the responsibility of deciding, at the idea level, whether or not to proceed. Here is the opportunity to take advantage of manufacturers field representatives who specialize in areas like lubrication, welding, bearings, materials, and so forth.

Training employees can make a

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Marquette Cement Manufacturing Company Cartersville Quarry			
MAJOR INSPECTION 50,000 MILES (DIESEL)			
Tractor No.	Mileage at Inspection	Date	
Symbols for Checking: ✓ If O. K. X—Adjusted O—Repairs Made			
Refer to Manufacturer's Maintenance Manual for Instructions and Information.			
ENGINE	Sym.	TRANSMISSION	Sym.
Clean Engine and Warm Up 150°F		Check Transmission for Loose Bolts	
Fan Belts. Check Tension to Manufacturer's Specified Pound Pull		Check Transmission Mountings	
Air Cleaners. Tighten Connections. Keep Airtight		Check Transmission for Oil Leaks	
Fuel Filters. Drain Water and Sediment. Change Element		Clean Transmission Breather	
Inspect Oil and Fuel Lines for Leaks		Check Transmission Manifold for Bearing Wear and Loose Flange	
Fuel Pressure. Check Pressure on Gauge Between Fuel Pump and Distributor at Governed Speeds to Manufacturer's Specifications		Drain and Refill	
Tighten Exhaust Pipe Connections and Check for Leaks. Inspect Supports		Check Auxiliary for Leaks	
Oil Pressure. Check for to Pounds. Idle to Pounds at Max. R.P.M.		DIFFERENTIAL	
Cylinder Heads. Tighten Stud Nuts to Manufacturer's Pound Torque		Check Pinion for Bearing Adj.	
Valve Tappet Clearance. Check with Engine Hot. Idle. Inlet. Exhaust		Check Pinion Seal for Leaks	
Manifolds. Tighten Stud Nuts and Check Gasket		Check for Loose Carrier Studs	
Fuel Pump. Clean Screen Per Manual. Check or Lbs. at Idle Speed		Clean Breather on Banjo	
Injection Fuel Inlet Connection—Clean Screen. Test Operation of Check Valve. Should Break at Manufacturer's Pounds to		Check Axle Flange and Gaskets	
Injectors. Check Spray Pattern Per Manual. Replace Injector. Tighten Stud Nuts to Manufacturer's Pound Foot		Check Two Speed Shift	
Engine Mountings. Inspect and Tighten		Tighten Studs—Drain and Refill	
Series Parallel Switch—Tighten Terminals		ELECTRICAL	
Governor Speed—Check Gov. Speed and Record		Check All Lights and Wiring	
Timing Gear Case Cover and Lower Crank Case. Check Tightness of Nuts and Inspect for Oil Seepage		Check Horn—Air and Electric	
Radiator Shutters—Adjust Settings to Open. -F Close. -4P		Check Dash Instruments	
CLUTCH		Check Voltage Regulator and Setting	
Check Clutch Pedal Play (1½ in.)		Check Cab Heater Motor	
Check Clutch Release Bearing Clearance		Clean Generator	
Check Clutch Control Rods and Pins		Check Generator Output	
		Check Generator Brushes and Terminals	
		Check Starting Motor Brushes, Terminals and Mounting Bolts	
		Check Generator Mountings	
		Check Batteries for Corrosion	
		Check Battery and Grease Terminals	
		Clean Battery Tray	
		Record Battery Readings with Hydrometer	
		Check and Tighten Battery Terminals	
		Check Battery Cover	

Fig. 4. Periodic inspection of equipment by a qualified observer will uncover a soon-to-occur breakdown. A typical inspector's check list used by Marquette is shown above

company better. Training is a host of things and it is available in many ways. A company should take advantage of a supplier's contact with the manufacturers to conduct informal classroom discussions and shop demonstrations in welding, lubrication, and engine maintenance, with specialists in these fields doing the instructing.

Parts books, prints, and instruction manuals are a vital part of a maintenance function. They are an absolute necessity for a crew making a first repair. A procedure should be established by every company for procurement and distribution of these important items. One copy should be kept permanently in the plant engineer's office and two copies, one for shop use, should be kept in the store-room. The intelligent use and care of these sources of information will pay off in time saved many times over.

While on the subject, maintenance benefits that can be derived from op-

erator training in the proper and safe use of equipment should not be overlooked.

Efficiency of the Maintenance Worker

At the 1961 Plant Maintenance and Engineering Conference in Chicago, a statement was made by an authority that the efficiency of the average maintenance worker is less than 50 percent. It is suspected that what is meant by efficiency here is simply that the average maintenance mechanic works four hours and is idle four hours. However, it may go deeper than this and include a rating in the mechanic's ability to do the job right in the shortest possible time. This low figure is due to management shortcomings!

To increase productivity it is first necessary to measure it, using the technique known as work sampling. This is a method of observing the mechanics at various times during the

work day and noting on paper their exact task or occupation at the first instant of observation. Enough observations are obtained to make the totals statistically reliable. A category (such as idle, traveling, working, etc.) total when divided by the total number of all category totals (or total observations) gives the percent of time that is spent day in and day out in that particular category.

With this knowledge, the supervisor will know what corrective action to take and should take it.

Communications Often Weak Link

First line supervision is incapable of initiating a program such as has been outlined so far, much less sustaining it. His problem has always been to get something fixed, to keep his people busy. He requires help from his supervision, and they from theirs. Some money must be spent, some clerical help is necessary and some decisions must be made. He can't and won't do it alone.

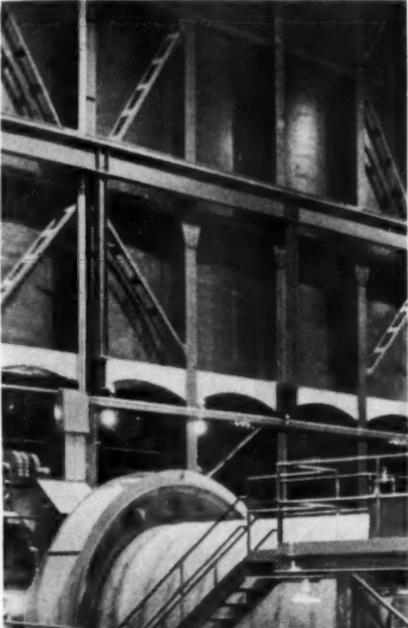
Communications often are a weak link in the maintenance management chain. Are the instructions to the mechanic by his foreman clear? So many times an honest misunderstanding results in wasted effort. Improving communication involves emphasis, repetition, and at times foreman training.

Are the jobs well planned and scheduled? Do the mechanics often wait because materials aren't on hand? Or a group from another department has not shown up? Or is some promised equipment not available? Or worse yet, is the foreman delayed somewhere while the mechanic waits for his next job assignment? Preventive maintenance will permit multiple job assignments to keep the man busy all day. To improve the planning and scheduling effort requires training of supervision in the fundamentals of foremanship.

Are parts available in the store-room when needed or is this a source of job delay? Would parts delivery by truck at a telephone request reduce the travel time by mechanics? Possibly the spare parts program needs overhauling.

Is management active to reduce equipment service severity? Are the roadways kept reasonably smooth? Are roadways sprinkled to reduce tire wear and keep the dust down? Is the equipment constantly overloaded without good reason?

These are some of the questions top management must ask and answer if it is to analyze and improve its maintenance effort.



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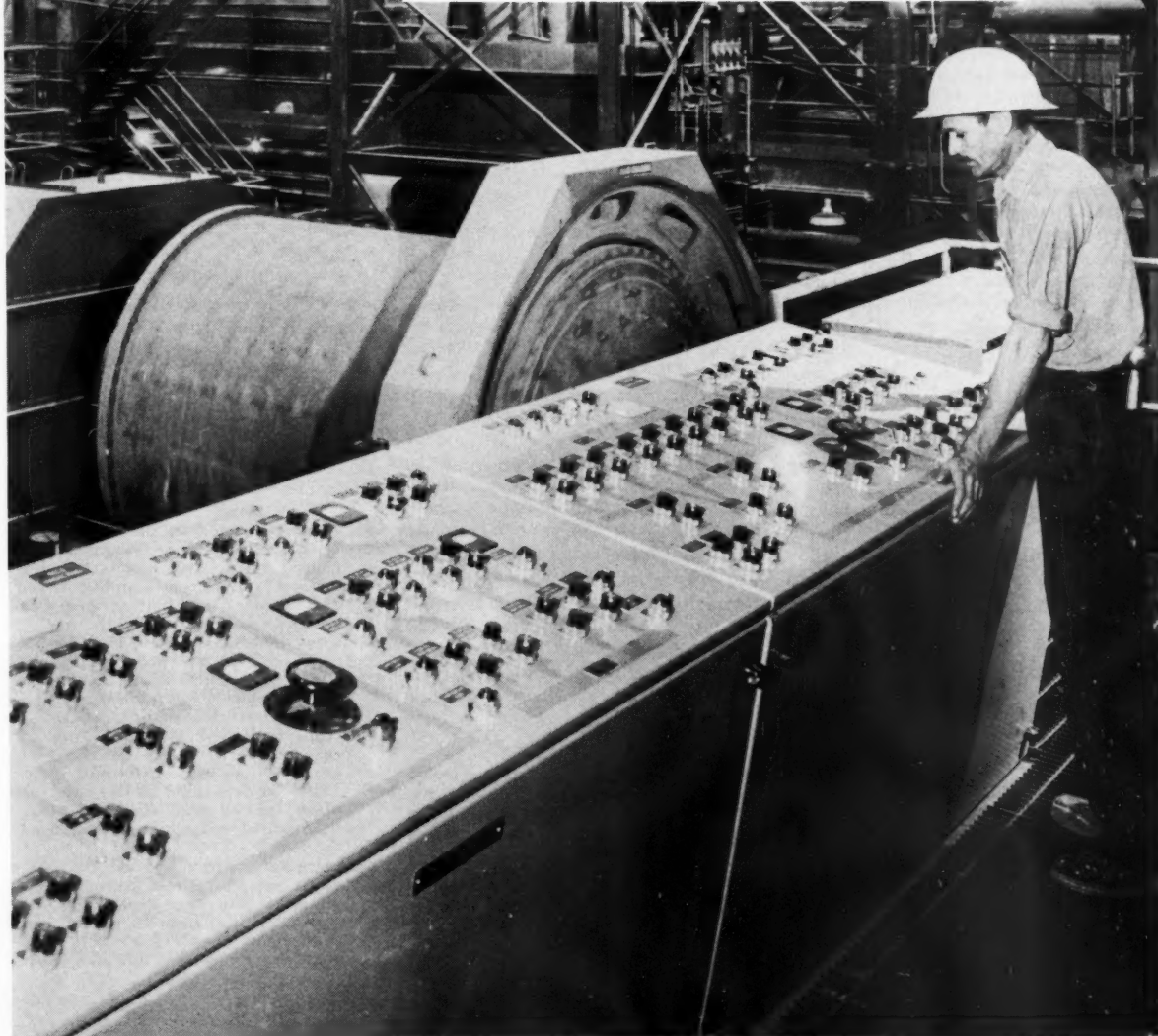
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By S. WEINBERG

Chief Engineer (Specialist Services)
National Coal Board
United Kingdom

Improvements in Conveyor Belting in the United Kingdom — Part I

Research and development program
in the UK has led to increased safety
and lower conveying costs

IMPROVEMENTS in underground belt haulage in the United Kingdom center about the rapid development of polyvinyl chloride (PVC) belting. Originally, the need was to satisfy safety requirements of the National Coal Board (NCB) with regard to fire resistance. Belts are available now, however, which have mechanical properties superior to those available at the beginning of the development period. These new properties are producing substantial savings in conveying.

5500 Miles of Conveyor in Use

The magnitude of the problem can best be illustrated by a rough description of the operations of the NCB. The NCB consisted originally of 1000 collieries and now consists of about 800 collieries, with shafts averaging about 1100 ft deep but varying up to three times that figure. There are some 35,000 conveyor driving units. About 24,000 of these are belt conveyors which account for 87 percent of the total conveying length, and a total belt installation of 28,000,000 ft (5½ thousand miles) according to figures available for 1960. This length is made up of 3-4 million ft of face belting on conveyors up to 150 yd long and averaging 90 yd; 14-15 million ft of gate belting on conveyors averaging 260 yd long, and 9-10 million ft of trunk belting of average length 400-450 yd per driving unit. Approximately a million horsepower are used to power these units, with 95 percent of this being electrical drives and the remainder compressed air drives.

During the ten years from 1940 to 1950 a number of fires occurred on belt conveyors which were of conventional multi-ply construction with rubber covers. Conveyor fires formed the second largest class of all underground fires, exceeded only by fires due to spontaneous combustion of coal or other carbonaceous material. More deaths were caused during this period by fires originating on conveyors than by all the other classes of underground fires combined. The worst incident occurred during September 1950 when a disastrous fire

took place at Cresswell Colliery, Derbyshire, killing 80 men. In the report of His Majesty's Chief Inspector of Mines in April 1952 it was stated that the fire "... started by frictional heating of torn belting jammed between the top of the sloping chute plate and the moving No. 2 belt as it passed round the delivery roller at the top of the chute at the No. 2 transfer point." One of the recommendations: "As soon as they are proven in practice and are commercially available, only belts which are nonflammable (the British Standards Institution has now adopted the terms 'flammable' and 'non-flammable') or are highly resistant to fire should be used."

Analysis of Belt Fires Revealing

Some important work on the problems of conveyor fires had previously been carried out in other countries but the resulting recommendations were mainly for guidance in installation and improved maintenance. At the NCB Research Establishment the problem was considered from the point of view of the intrinsic prop-

erties of the belt itself, and projects were organized to determine the origin and the causes of conveyor fires, and then to seek means for their prevention.

The first step was an analysis from all available records with the object of classifying fires as to origin. Three clearly defined classes emerged:

1. Fires generated in the belt. These were fundamentally frictional fires caused by driving drums rotating against stalled or slipping belts, and strips of torn belting wrapping around revolving shafts;
2. Fires generated in other parts of the conveyor system. These fires occurred mainly at the rollers or idlers, where overheating caused by rotation against obstructions or from collapsed bearings, and, in rare cases, from overheating of gears, couplings, or tension ends. The heat generated in this manner often ignited coal dust, or other flammable material, and spread the fire.
3. Fires originating outside the conveyor system. These were in the minority, and were caused, for example, by deficiencies or failures in adjacent electrical or compressed air power systems.

The first two classes, accounting for

more than four out of every five fires, were clearly fires generated by frictional heating whereas the third was propagated and intensified by the belt itself.

Hazards Evaluated and Tests Developed

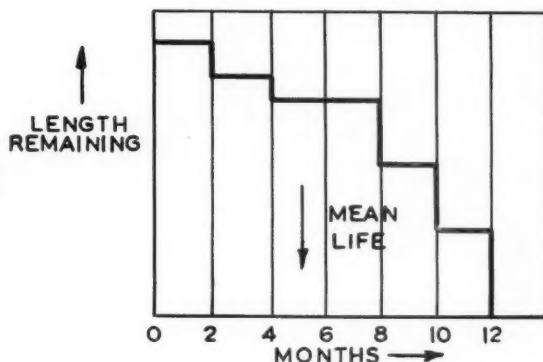
All underground belting would have to be of a type which would resist these hazards, and as a first step it was necessary to devise reliable tests to determine the requisite belt characteristics. It was clear that two tests would be necessary, one to indicate resistance to ignition by frictional means and the other to measure the tendency to propagate fire on application of an external flame. Arguments often have been advanced that only the second hazard need be considered, but, in the early investigations, examples were found both of belts which would propagate a fire but would not ignite on frictional heating (e.g. belts with rubber covers and chemically treated, fireproof carcass), and of belts which would not propagate direct flame but would glow or burst into flame when stalled against a rotating drum (e.g. belts depending on melting covers for fire resistance). Some belts, normally non-flammable, presented other hazards; those with glass fibre fabrics produced a dangerously high temperature in frictional heating conditions; those containing metallic strands threw off glowing particles. These and similar types demanded a frictional test as well as a direct flame test. Reproduction of the hazards were made on almost full scale, during which belting was subject to direct flame and to fires caused by friction, including those produced by defective rollers running in coal dust or other flammable material.

The tests were conducted on the following types of belting composed of:

- a. Conventional rubber with cotton duck, both new and used,
- b. Rubber with rayon duck,
- c. Neoprene with cotton duck,
- d. Rubber with fireproof duck,
- e. Treated rubber with cotton duck,
- f. Rubber/Neoprene mixtures with cotton duck,
- g. Solid woven untreated cotton with PVC covers, etc.

The results of the tests were found to be reproducible and were carefully correlated with the large scale experiments. Two tests were devised and later incorporated in specifications, one test known as the NCB Flame Test and the other the NCB Drum Friction Test.

Fig. 1. Decrease in belt length with respect to time belt operated



It had been found that none of the types of belting listed above complied with NCB specifications. A recommendation was made that rubber be replaced by PVC which, when suitably plasticised, is self-extinguishing. This characteristic is proof against the propagation of flame, and when PVC is heated it melts, impregnating the underlying fabric, rendering it safe against frictional hazards.

From these tests and recommendations both multi-ply and solid woven fire resistant PVC belts, first with cotton and later with man-made and synthetic fibres, were successfully developed.

Notwithstanding all these tests for safety requirements, the belts had to fulfill a duty and in the course of development the mechanical and physical characteristics were in the forefront of all considerations.

It was necessary to be able to measure the performance of conveyor belting in order to have a reference point from which to proceed and, the NCB's Field Investigation Group was called upon for help. This Group, specializing in operations research techniques, devised a statistical method for examining belts while in service, which was then used to set up an Approval system.

Approval System Halts Purchase of Substandard Belting

The Approval system was introduced to assure that purchases would be confined only to belting that was safe, i.e. fire resistant (and later anti-static) and of such quality that it would give reasonably satisfactory performance in service compared with standard rubber and canvas belting which was the "norm" in those days.

The initial system has been modified as described below, but even now the principle of Approval is still maintained and only "approved" belting, i.e. belting that has received

an NCB Approval Number, may be purchased. The grant of an Approval Number is made for an individual belt which has successfully passed the laboratory tests and trials specified in a procedure for approval. These originally comprised:

First Stage Trials

1. Laboratory tests on sample belts submitted by a manufacturer to check compliance with the specifications;
2. Operation pit trials on moderate quantities to assure that the belt's service performance was satisfactory, and to assess for classification.

Second Stage Trials

Additional pit trials of production lengths of the belt to assure that the manufacturer was capable of producing satisfactory belting in bulk.

Early in the development of fire resistant belting it became evident from field observations that significant belting failures rarely took place before about the fourth month of service. It was decided, therefore, to specify a period of six months for the operational pit trials in the first stage. A further six months was allotted for second stage trials. As the period needed for the laboratory tests was one month, the total period required for approving a belt was originally a minimum of 13 months.

The grant of an Approval Number was made in two stages, a Provisional Approval Number at the end of the first stage, subject to the deposit in confidence by the manufacturer of a satisfactory specification for the belt; this was merely a basis for uniformity of production. A limited amount (normally about 4500 ft) of the belt was then purchased for allocation to second stage trials. Subject to satisfactory reports from the field of these trials, the Provisional Approval was confirmed to a full Approval and the belt then "released"

for purchase in bulk quantities. It is important to note that the grant of Approval was made for a specific belt, not for a range of belts or types, against the manufacturer's deposited specification for that particular belt, and that any subsequent variation or alteration of the specification (or the belt) not agreed to by the NCB could be grounds for withdrawal of the Approval Number.

Satisfactory identification was and is still obtained by belt cover color and specified markings (e.g. Approval Number and month and year of manufacture) on one face of the belt. Each manufacturer was allocated an identification color and was also required to specify a Reference Number for the sample submitted for testing under the approval procedure. This procedure enabled correct identification of a belt from sample to fully approved production.

Obviously, development in the early stages of fire resistant conveyor belting was rapid, and since few manufacturers had the test facilities to make their own prior assessments, a large proportion of the early samples submitted for Approval were found to be unacceptable. For that reason the length of time involved in the whole routine was irksome. The chief difficulty being the relatively slow rate of acquisition of information from mine installations spread in a cross section around the country.

A further examination was requested of the Field Investigation Group and it was demonstrated that the method of assessment of belt life

gave graphical representation of the same shape whether for trunk, gate, or face conveyors—as shown in Fig. 1—the difference being the scale of the ordinates; these were loss of footage plotted against time of operation. It thus became possible to choose a system of face conveyors at one colliery in the North Eastern Division which gave a very fair representation of the varying conditions of conveying—by gradient, wetness, instability of ground, arduousness of duty, etc.—and within the relatively short time of six months could produce an acceptable assessment of belt samples. This length of time was the approximate life of a belt on face work. In all the tests two or more “norms” were used to correlate the results of each set or batch of trials with the others.

It is interesting to note that the standard conventional rubber belt originally used as a norm was a target of quality and was easily at the top of an order of merit of experimental PVC belts; it is now right at the foot of practically every batch of 10 or 12 belts and represents the lowest quality acceptable. On the other hand, one of the norms is the best fire-resistant belt available; this assures that the target is the highest. Up to now it has been a solid woven belt.

Limited Approval Expedites Program

The increased drive given to development by the introduction of synthetic fibres in the belt fabric, and the

production of markedly superior belting using these fibres, made it necessary to seek some means to quickly prove these “Premium” belts so as to be in a position to take advantage of the manufacturers' initiative and also, of course, encourage this trend in development. It was evident that the time required under the Approval system for proving a belt had become unrealistic for Premium belting and was likely to retard development, especially since experience was now extensive. Furthermore, the increase in quality was such as to render the six months of operational trials too short a period in which to produce evidence as to belt life. Since these belts were by their nature more expensive in first cost, although more economical, it was necessary to limit the rate of intake so as to control the outlay (especially since some period of stocking was inevitable). It was decided, therefore, to expand the approval system by the introduction of a Limited Approval which would be granted for belts whose types of construction were already familiar. Belts selected for technical excellence and commercial considerations can now be granted Limited Approval at any stage subsequent to the laboratory trials. Fairly substantial quantities are purchased, allocated for pit trials under control and observation, reports being furnished as called for, without any time restriction. It is possible now for a belt granted Limited Approval to be released for bulk purchase by the confirmation of the Limited Approval to full Approval within a relatively short time of the

Reason for removal	Warp damage			Weft damage			Weft & warp damage			Other reasons				Combined reasons						
	Breaks	Edge splits	Too short	Longit. edge tearing	Rip-ping by jam-ming	Tear-ing out and long-it. crack-ing	Holes and slits	Joints	Un-spec. dam-age	Burns	Edge de-lam.	Ply separ.	Roof falls	Edge splits and holes	Nar-row and slits	Edge splits and burns	Joints and edge splits	Ply sep. nar-row and joints	Burns and long-it. edge tear-ing	
Trial																				
Group I Faces	2.1	0.1	0.6	18.7	2.1	0.1	—	5.1	26.3	—	1.1	4.8	2.2	—	—	—	—	—	—	
Group I Gates & Trunks	0.7	5.8	0.4	9.8	—	4.0	1.3	3.5	8.6	—	—	4.8	—	—	—	—	—	—	—	
Group 2 Faces	8.4	5.4	1.5	13.6	3.1	4.7	—	3.3	26.2	—	—	—	2.7	—	—	—	—	—	—	
Group 2 Gates & Trunks	2.6	—	—	0.4	2.6	1.3	0.6	1.1	5.4	—	—	—	—	—	—	—	—	—	—	
Group 3 Batch 1	2.9	0.3	3.3	13.7	7.9	1.5	6.9	5.6	3.7	1.2	—	0.1	11.2	0.4	1.0	0.8	—	—	—	
Group 3 Batch 2	1.8	3.1	2.4	11.2	11.1	8.0	6.7	5.5	2.9	1.9	—	1.8	10.7	2.6	0.2	—	0.2	0.7	0.4	

(Extracted from “Types and Frequency of Damage to Conveyor Belting” N.C.B. Report S.C. 410)

Fig. 2. Reason for belts taken out of service and percent of belt removed as percent of length installed

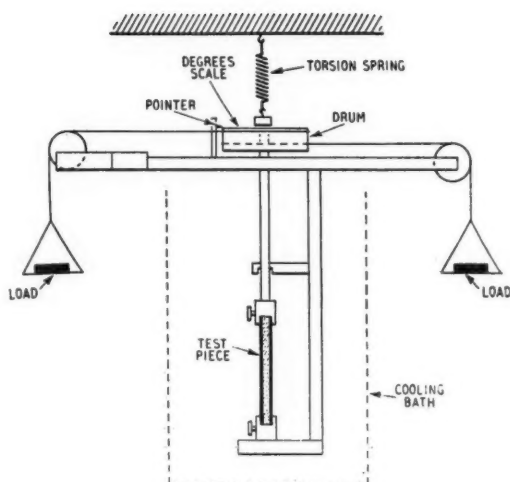


Fig. 3. Rigidity modulus apparatus

sample having satisfactorily passed laboratory tests.

Knowledge of Belt Damage Aids Improvement Efforts

An important step forward in the development of belting was achieved in July 1957 when a report was issued on the "Types and Frequency of Damage to Conveyor Belting." It had been early realized that the development could only go so far, and no further, since a portion of the reasons for losing or removing belting were not within the control of the design engineer; these were ground shifts or roof falls, etc. There could therefore be set by statistical examination an economic limit to the improvement in life attainable. The other reasons for loss of belting could be classified, for example, as wear and tear, random damage, bad installation, and bad maintenance and if the effect of these could be reduced, the development limit could then be raised and a higher target for belting life made possible. Installation and maintenance were external engineering problems, and only wear and tear random damage need be considered as immediate and intrinsic belt problems.

Trials were made to determine the relative importance of different forms of damage and reasons for removal of belting, and it was found that the pattern of damage on gate and trunk conveyors was essentially the same as on face conveyors, the rate being different. The contribution to the amount of removed belting by various forms of damage differed with type of damage. Belt breaks and joint failures were not important causes of removal, but they disrupted production. Edge wear and ripping by jamming were the most important reasons for

removal. Lateral edge splits and longitudinal cracking, though occurring quite frequently, were not very important. Slipping was a minor cause of removal. Roof falls, of course, invariably led to a high loss of belting. Fig. 2 shows some of the tabulated results of these trials.

The types of damage were divided into three categories: weft damage, warp damage, and other forms not related to the strength of the belt on either warp or weft sense. Weft damage was considered the most important, and recommendations were made as to the lateral strengthening of belts and that tests should be devised to develop satisfactory weft properties.

A most significant feature of this work was that there was no positive evidence that damage was dependent on time, and no evidence that continuous wear played any part in the removal of belting from face conveyors. In the previous usage of rubber belting a cover thickness of 3/64 in. was usual. If wear was relatively unimportant, and since PVC is more resistant to abrasion than rubber, could this thickness be reduced and thus save material costs? It was decided to standardize on a thickness of 1/32 in. thus saving, at the rate of which belting was being purchased at that time and at current prices, more than a £million (\$2,800,000) per year.

Mechanical Properties of PVC Belting Improved

Some of the early attempts at plasticized PVC produced hard, glossy, (and therefore low friction) covers. These covers were brittle and became more so at low temperatures and as a result gave rise to a familiar cracking by embrittlement. These,

and many other problems, were identified and isolated. Recognizing that by now belting manufacturers had vast facilities for development compared with the Board's Establishments, it was decided to offer each of them some specific problem to solve. One investigated the effect on the various mechanical properties of different proportions of chemical compounds, i.e. whether increased flexibility was accompanied by a reduction in other characteristics. The result of this program was the immediate solution of the embrittlement problem. Figs. 3 and 4 show the apparatus used, and the test results using different proportions of plasticizer.

Another manufacturer studied flexibility at very low temperatures—since PVC, like rubber, tended to become stiffer and therefore less "driveable." A third attempted the whole problem of coefficient of friction; still another, the requirements for operation in wet conditions, and so on. Out of all these investigations a very comprehensive knowledge of the behaviour of a belt

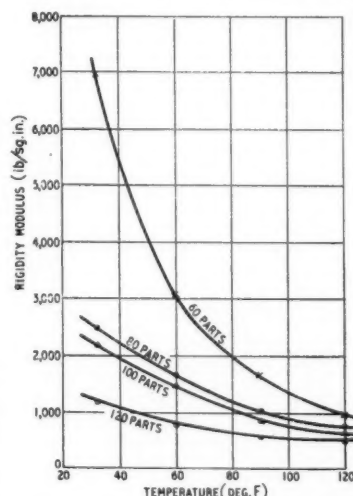


Fig. 4. Flexibility (rigidity modulus) test results using different proportions of plasticizer

in operation in relation to its various tested properties was rapidly accumulated. Technical liaison was maintained at a high level between representatives of the manufacturers, and the NCB's engineers, scientific control personnel, and research and development establishments. The latter began to interpret the results in terms of tests which, after experience and adjustment, became the basis for standard specification requirements. One of these recently issued was a tear test simulating tear in operation and arranged in the manner shown in Fig. 5.

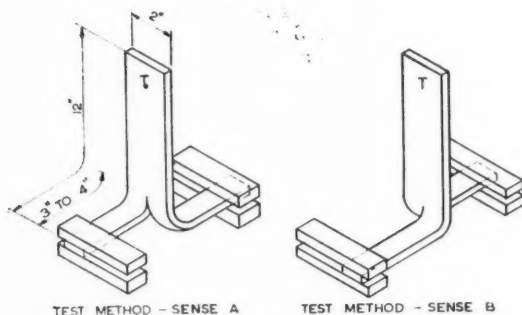
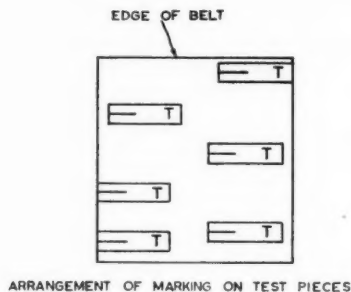


Fig. 5. Tear test arrangement used to develop standard specifications

Electrostatic Hazard Eliminated

Around this time a new hazard was highlighted, chiefly in the Dur-

ham Division. One of the properties of PVC as used in many other commodities, notably in the field of elec-

trical engineering, was its electrical insulation or high resistivity. On some conveyors, mostly operating in dry conditions, an electrostatic charge was being generated and maintained; this charge gave rise to sparking which was clearly undesirable and, in some circumstances, very dangerous. The possibility of building up a high voltage, accompanied by a sufficiently heavy charge to produce sparks which could ignite gas mixtures, was demonstrated and a crash program to eliminate this hazard was organized. All the available evidence on generated voltage was collected, a mathematical examination proved unsatisfactory in view of the many types of construction, and a stipulation of the criteria was made empirically from the envelope conditions as shown plotted in Fig. 6. Many difficulties were encountered, but eventually the appropriate characteristics were achieved and, as a result, only antistatic belts have been purchased since—with not a single occurrence of sparking having been recorded.

Part II of this highly informative article will be carried in the October issue of Mining Congress Journal.

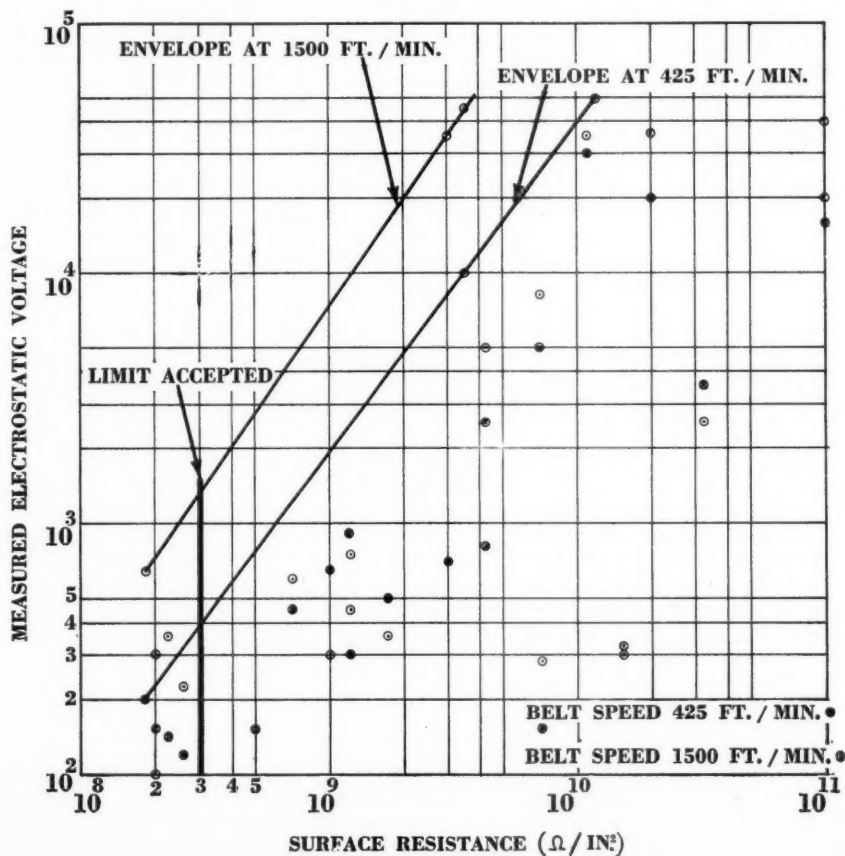


Fig. 6. Test data used for determining electrostatic properties of belting shows surface resistance versus electrostatic voltage

OPERATIONS research by its very name is identified as an essential part of operations. Too many of us, perhaps, have seen the complicated mathematics frequently associated with articles on operations research (OR) and have consequently dismissed them with the comment, "These are for the research boys, the mathematicians and the longhairs." It is the purpose of this article to show that some of the techniques of operations research can be used by mine operators to reduce costs.

A person does not have to be an operations research professional or mathematician to be able to think clearly, and in accordance with the rules of logic, and to use statistical methods to analyze and consequently reduce costs. It is doubtful that operations research or even the monster modern computers will ever replace the God-given common sense of an experienced and alert manager or superintendent. But the writer can testify from personal experience that the techniques of modern logic and mathematics that are frequently called "Operations Research" can be used to reduce all sorts of costs in a mining enterprise.

Of the 50 or so papers dealing with OR that the author has read or heard in the last five years, about half have in one way or another attempted to define operations research. This is somewhat like trying to define "thinking"—the field is so broad and the terminology so confusing that no single definition seems to fit. A definition will not be attempted here but some statistics and examples of studies, which at least have some of the earmarks of OR, will be presented.

"Models" Describe Repetitive Situations

One of the principle earmarks is insistence on a rigorous discipline of scientific treatment. Objectives must be clearly stated, assumptions listed, some scale of values used to compare alternative courses of action, and almost always some form of "model" must be used.

This word model is frequently misunderstood by persons not familiar with the terminology of operations research. Models may take many forms; scale models of aircraft in a wind tunnel, a laboratory pilot plant of a metallurgical process or a mathematical equation which describes some characteristic of an operating process. To everyone except an operations research purist, a mathematical model and an equation are one

Cutting Costs

THROUGH OPERATIONS RESEARCH

By JAMES L. COX
Minerals Expansion Engineer
International Minerals &
Chemical Corp.

An analytical approach to operating problems can show the way to reduced costs

and the same thing. One such model is shown below:

$$x_{1n} + x_{mk} + \sum_i x_{1(i)} \geq x_{mu} + x_{1k} + \lambda$$

$$\lambda = \sum_i x_{1(i)}$$

This equation was derived from a linear programming matrix used in an equipment location study.

Another mathematical model consists of the following equation:

$$C = 34.17 (M + V)$$

Where:

C = Dragline operating cost
M = Cubic yards of ore
V = Cubic yards of overburden

This model describes the direct cost of operating a dragline in strip mining.

Probably relatively few mining men comprehend the meaning of the first equation, (certainly the author does not). Practically any operating man, though, can understand the significance of the dragline cost equation. Both equations are now being used in studying real problems.

The point is this; just because some OR studies involve the use of advanced mathematics does not mean that the techniques of operations research cannot be used to assist in solving mining problems and reducing costs. A great deal can be accomplished with the proper use of high school algebra.

Perhaps the most important characteristic of a model is that it have a high correlation with the real world.

It may be fairly simple to demonstrate a correlation between some middle-aged men's weights and the amount of popcorn and beer they have consumed during their lifetime. It would be impossible to demonstrate a correlation between their weights and the color that their wives' hair dresser will impart next week. In other words, a model must reflect the cause and affect relationship that really exists in a repetitive situation.

Method for Testing Correlation

A model that has been demonstrated to have a high degree of correlation is the relationship between maintenance costs in a beneficiation plant and the kilowatt hours of electricity used in operating that plant. The logic of this is simple; the more a plant runs, the more kilowatt hours it consumes and, of course, the more maintenance it requires.

Error in statistical analysis, such as the one a friend of the author's recently made, should be avoided. One morning he was hung-over after drinking scotch and soda the night before. The next night he drank bourbon and soda. Again he was hung-over, so he drank vodka and soda. In the midst of his third hang-over he statistically analyzed the problem and resolved to stop drinking soda. The point is this: be sure that the cause and affect relationship is not clouded by outside influences. One of the most frequently occurring outside influences in modern business

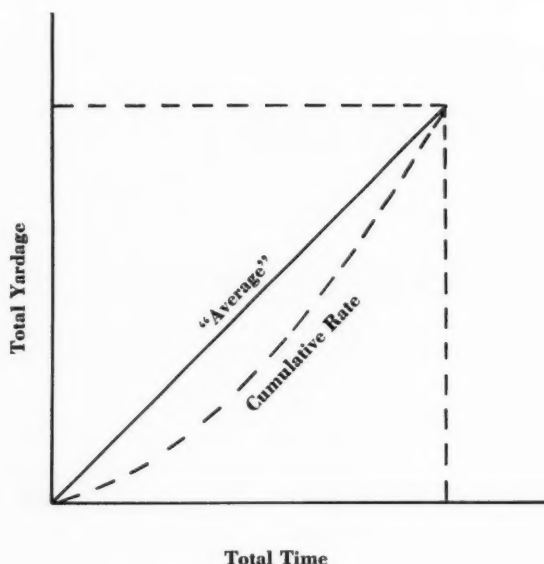


Fig. 1. In studying almost any operations research problem, some form of "model" must be used, and the model must reflect a cause and effect relationship that exists in a repetitive situation. A cumulative plot, such as the one shown here, is a simple technique for testing the degree of correlation in a model

is introduced by cost accounting principles, which result in the allocation of many noncorrelated costs.

A simple technique for testing the degree of correlation is cumulative plotting. Figure 1 shows a simple version of this cumulative plot. Assume that the operating time shown is 7000 hours and that during this time, 7,000,000 yd are moved. The average line represents an average rate of 1000 yd per hour. The cumulative plot shows the hour-by-hour rate of yardage movement.

This kind of plot tells several things. If the hour-by-hour yardage measures approximately a straight line, it is certain that a high degree of correlation exists between time and yards moved. If the points are widely scattered, some other relationship must be found to use in the model for describing the real situation.

OR Approach to Grade Cut-Off

Another piece of intelligence which can be derived from this plot is that the circumstances surrounding the time during which the curve is steeper were such that hourly capacity of the hypothetical earthmover was appreciably higher than at other times. Further research may show why this curve was steeper and perhaps arrangements can be made for this higher hourly capacity to be achieved for a higher percentage of the total time. It follows, of course, that if the hourly production of the earthmover can be increased, that a cost reduction per cubic yard follows.

Almost every mining supervisor sooner or later must face a grade cut-off decision. He must answer the question, "How low grade an ore can I mine at this pit and process through this plant and still make a profit?" The operations research approach to answering this question would involve the following elements:

1. State the problem—how low grade, etc.
2. Form a "team"—a mining engineer, a metallurgist, an accountant, and a salesman.
3. Construct a model—it would probably be like this:

$$\begin{aligned} \text{Profit} &= \text{Sales price minus cost} \\ P &= \$27.00/\text{ton} - [3.10 (V) + 8.05 F + K] \\ V &= \text{Volume} \\ F &= \text{Feed Grade} \\ K &= \text{Fixed Costs} \end{aligned}$$

4. Operate the model, i.e., use appropriate tonnage, grades, fixed costs, etc., to determine cost and profit.

This appears to be simple enough, and certainly it is; operators have been using such a calculation for years. It is this that leads to the contention that this is operations research; that OR can and should be used as a cost reduction tool.

Example of Productivity Gain

Another example—International Minerals & Chemical Corp. operates a multi-mine, multi-plant phosphate complex in Florida. The internal movement of product (by rail) from one location to another is relatively costly. The company recently faced the necessity of adding an additional locomotive and crew to its fleet. The

operating superintendent of the department concerned knew that the extra demand was for an additional five shifts per week which was not great enough to justify an additional locomotive. Being an alert manager, he got a team together to study the problem.

The team consisted of a transportation foreman, a weightmaster, an accountant, an industrial engineer, and himself. The age-old and obvious answer immediately occurred—an additional locomotive would not be needed if more productivity could be gotten out of the existing ones. The locomotives and crews had already been time-studied and the productivity level for the tasks assigned seemed satisfactory. A "model" describing the time distribution of an existing locomotive during a shift was constructed. This model was similar to the following one:

$$\begin{aligned} T &= R + W + S \\ 8 &= 3.9 + 3.0 + 1.1 \end{aligned}$$

$$\begin{aligned} T &= \text{Total hours per shift} \\ R &= \text{Running time per shift} \\ W &= \text{Weighing time per shift} \\ S &= \text{Stand-by time per shift} \end{aligned}$$

In looking at the time distribution equation of the locomotives, the high percentage of time used for weighing cars of rock was questioned. One member of the team suggested adoption of a sampling routine for railroad car weights that would be based upon the same theories of probability used in sampling product streams.

It was a simple matter from this point to determine a sampling pattern such that the average weight of sample cars would represent the average weight of all cars with an acceptable confidence limit. In this case, ten percent of all cars were selected in accordance with the laws of chance. As the new routine was installed it was, of course, double-checked. It proved so reliable that the railroads and weighing bureaus are now accepting these weights for freight bill purposes on the company's internal rock movements.

The time saved by this change in procedure not only eliminated the need for an additional locomotive, it allowed for the reduction of five shifts per week in the existing locomotive schedule.

Some industrial engineers would insist that the technique described in the last example was time-study rather than operations research. Does it really make any difference? Call it time-study or operations research, an analytical approach to a problem resulted in a cost reduction.



Fig. 1.—The Zonguldak coal washing plant is in the heart of town, and efficient dust collection is essential. Primary and secondary dust collectors can be seen on the roof of the drying plant

Recent Progress in Thermal Drying Ultra-Fine Coal

Over 150 tph of filter cake containing up to 30 percent surface moisture is being dried to 5 percent surface moisture at a coal preparation plant in Turkey. Heat consumption is 3,173,000 Btu per ton of water evaporated

By RAYMOND E. ZIMMERMAN

Vice President
Paul Weir Co.

A great deal of information has already been published concerning the many devices used to dry coal with heat. Most of these dryers do a satisfactory job on particular size ranges of coal. The trend today appears to be in favor of the fluidized bed type for treating slack coal sizes,

and, unquestionably, this type of dryer is doing an excellent job.

However, in addition to the requirements for drying slack sizes of coal, an increasing problem is presenting itself in this country in the need for drying ultra fine sizes—the minus 0.5-mm or 28-mesh range.

This is a result of the rapid spread of froth flotation plants used to remove this material from cleaning plant slurry or recirculating water.

Either the economics of coal recovery or stream pollution laws, or a combination of both, has dictated the need to recover these fines. What-

TABLE I
General Data

Location of dryer installation	—Zonguldak, Turkey
Type of dryers	—Two Buttner "Rema Rosin" Flash dryers
Kind of feed	—Bituminous Coal Froth Flotation Filter Cake
Size of feed	—28 mesh x 0
Feed moisture	—25.2% (Surface)
Product moisture	—5-6% (Surface)
Dry dust collectors	—Two van Tongeren multiclones per dryer
Exhaust fan and wet scrubber	—Eck, dual inlet, water injection type, capacity 33,000 cfm @ standard conditions.
Furnace	—Refractory lined, air cooled, suspended arch, with a combustion chamber and an air mixing chamber, and automatic ash removal. Capacity, 62,000 Btu
Burner	—Twin pulverizer fuel burners using dust product from multiclones. Fuel oil burner used for initial start up.

TABLE II
Operating Results (per Dryer)

1. Wet feed	82.6 Short tons/hr
2. Water content feed (Surface moisture)	25.2 %
3. Water content product (Surface moisture)	5-6 %
4. Dried product	66.5 Short tons/hr
5. Water evaporated	16.1 Short tons/hr
6. Heating gas temperature (inlet)	1027° F
7. Vapor temperature (dryer exit)	239° F
8. Dried coal temperature	149° F
9. Heat consumption (Btu/ton water evaporated)	3,173,000
10. Dust content exhaust gases	0.073 grains/cu ft
11. Drying column gas velocity (top of column)	60 ft/sec
12. Power consumption	395 kw
13. Gases and vapor through exhaust @ 115° C	82,500 cfm
14. Wet scrubber (Slurry, dry basis)	860 lb/hr

ever the reason, its recovery has intensified the problem of removing moisture from the recovered coal.

The best we can usually expect from either centrifuges or vacuum filters is to reduce the moisture of flotation coal down to 20-30 percent. Beyond that thermal drying is required—by no means an easy task. Handling 20 to 30 percent moisture ultra fines, usually in the form of filter cake, is difficult. Evaporating the large quantities of water involved and preventing high dust loss after it is dried are problems of the first magnitude.

There are a few dryers on the market today that can properly handle this difficult material. Perhaps one of the solutions is not to dry it in its present form, but to pelletize it first—pelletize and dry in one operation. Research is being conducted at the present time to develop a practical and economical way of doing this.

Another good way to handle froth flotation concentrates, or ultra fines, is to concentrate it to pulp densities of from 60 to 65 percent solids and burn it directly in power plant boilers. Experimental work on this possibility is being carried on by one of the larger coal companies in this country in connection with long distance pipelining of coal.

However, as advantageous as these methods may be, the fact remains that in many situations it will still be

desirable to thermally dry minus 0.5-mm filter cake.

Drying 150 tph of Filter Cake

This article describes a thermal dryer installation where this is being accomplished successfully. It involves drying the product from a froth flotation plant treating as much as 120 to 150 tph of minus 0.5-mm coal.

The drying is being accomplished in Buttner dryers, manufactured by Buttner-Werke AG., Germany. They were installed under the direction of the Paul Weir Co. at Zonguldak, Turkey, in connection with the operation of the washery at Zonguldak.

Zonguldak coals are extremely friable and, although of high volatile bituminous coal quality, are somewhat similar to Pocahontas coals in their friability. As a consequence, the washery itself, handling 800 tph (short tons) run-of-mine feed, was designed to handle as much as 65 to 70 percent minus 1/4-in. Since the minus 0.5 mm, therefore, amounted to a very substantial tonnage of raw coal, it was desirable and necessary to provide a froth flotation plant. Tonnage to this plant ran from 120 to 150 tph.

The flotation plant filter cake product contained from 20 to 30 percent surface moisture. The large percentage of the washery product represented by this high moisture product required that it be thermally

dried, regardless of whether it was to be mixed with coarser sizes or shipped by itself.

This was accomplished in two parallel Buttner dryer systems of the Rema-Rosin type. This type of dryer is frequently called a "rapid recirculation" dryer and, in fact, is quite similar to what we in the United States call a "flash dryer."

Figure 1 is a general view of the washer. Primary and secondary dust collectors are on the roof of the drying plant. Since the plant is in the heart of the town of Zonguldak, it was essential that dust collection equipment be highly efficient.

Two Drying Circuits

There are two parallel heat drying circuits in the plant, as shown in figure 2. Each consists essentially of furnace (1), drying column (2), primary collectors (3), secondary collectors (4), exhaust fan and wet collector (5), entrainment trap (6), exhaust stack (7), wet coal feed hopper (8), paddle mixers (9), rotary air lock (10), rotary slinger (11), wet coal feed conveyor (12), dried coal product conveyor (13), secondary dried coal (dust) conveyor (14), primary furnace air blower (15), secondary furnace blower (16), and tertiary furnace blower (17).

Details of the bottom of the drying column are shown in figure 3. The saxophone shape (a) takes the heated gases from the furnace outlet (b). These gases come from a furnace which burns dust from the secondary

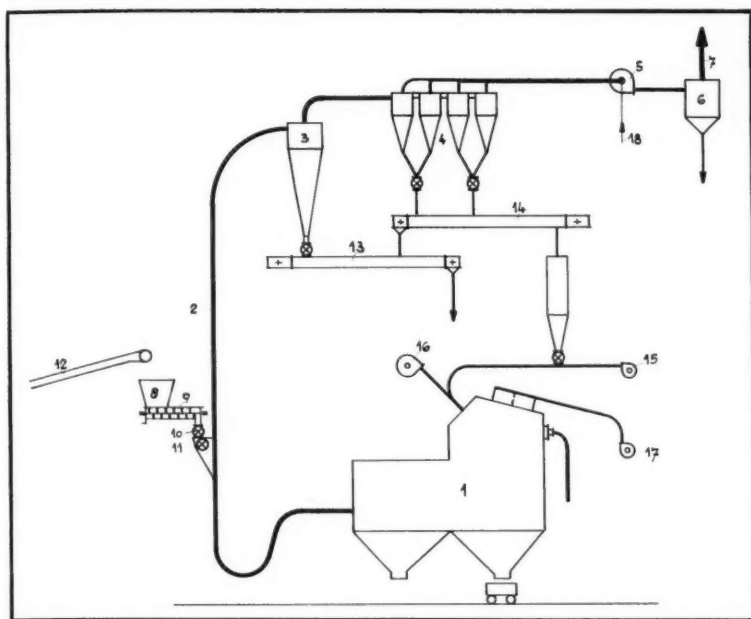


Fig. 2.—Flow diagram of the heat drying circuit at the Zonguldak plant (see text for explanation)

dust collectors. The furnace has a combustion section and an air tempering section where air is sucked in through louvres in automatically controlled proportions depending upon the temperature requirements. A refractory brick-constructed gate (c) permits the furnace to be sealed off during shutdown periods. The insulated 36-in. diameter stainless steel drying column (d) is approximately 50 ft high, and curves (e) into parallel primary cyclone collectors where the bulk of the product is collected. Electric heating elements (o) at this curved section prevent any possible build-up of damp coal.

Wet coal (filter cake) (f) is fed to the dryer column by a rotating slinger (g) which throws the coal into the column and gives a final chance to break up any lumps of cake still existing. A heating element (o) at this point prevents wet coal from sticking to the feed chute. A rotary air lock (h) prevents the escape of hot gases and excessive air leakage. A double paddle mixer (i) and a second paddle mixer (k) take wet coal feed from hopper (m). A dried product, to be mixed with the wet feed, can be fed through a section of pipe (l) if desired. This was seldom found to be necessary—generally only when filter

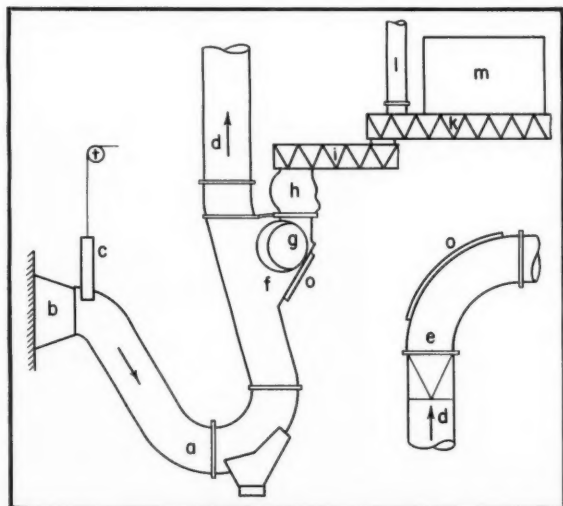


Fig. 3.—Schematic view of the bottom of the drying column, including the feed arrangement

cake moisture neared 30 percent.

The rotary lock, slinger and section of the drying column are shown in figure 4.

Table 1 summarizes general basic data concerning the Zonguldak dryer installation. Figure 5 is a schematic arrangement of the secondary dust collectors. They are multiclones of the van Tongeren design. They consist of two sets of four each of approximately five ft diameter cyclones. Intake gases and dust pass into a manifold (a) from the primary cyclone collectors. Dust drops (b) into hoppers (e) through rotary locks (g) and thence onto a conveyor (h) where fuel for the furnace passes into a hopper (i). Any excess dust combines with the dried coal. Exhaust gases (c) pass through a collector duct (c) and thence down (k) into the exhaust fan. Special plates (d) will rupture in the event of an accidental explosion. There is very little chance of this taking place and, in the course of our operations it did not happen at any time.

Dust Collection

Figure 6 is a cross section of the combined exhaust fan and wet dust collector. The drive shaft (a) from a direct-connected motor operates impeller blades (b) of the Dr. Eck design. The blades are made of Thermax. The casing (c) is lined with acid-resistant tiles. There are two suction inlets (d), air inlets (e), water injection spray nozzles (f) and water and slurry outlets (g). Air volume is regulated by a spinning device (h) which can be adjusted by remote control from the plant control station. At

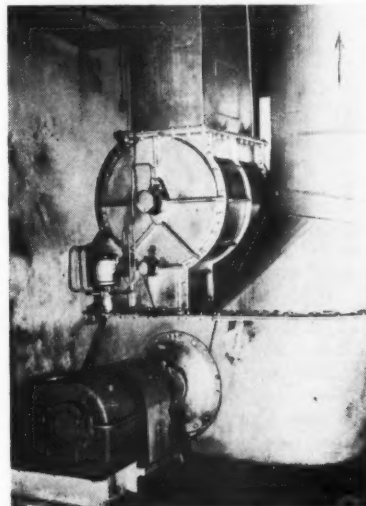


Fig. 4.—Wet coal is fed through a rotary airlock (center) to a feed slinger (lower left) which passes it into the bottom of the drying column (right)

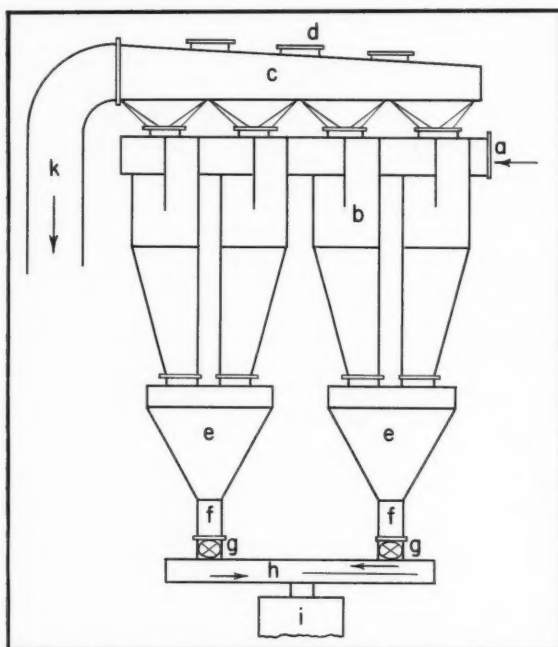


Fig. 5.—Schematic arrangement of secondary dust collectors

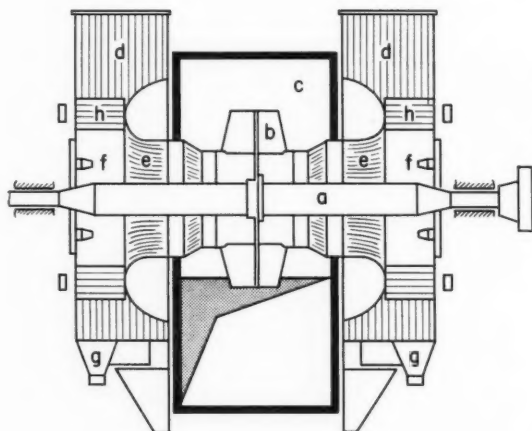


Fig. 6.—Cross section of the combined exhaust fan and wet dust collector

115°C. it was exhausting 82,500 cfm of gases and vapor and pulling 22 in. of water gauge.

Gases and vapor from this fan are discharged into an entrainment trap at the bottom of the exhaust stack. This and the stack is shown in figure 7, a photograph of one end of the heat drying plant. The entrainment trap is simply a cyclone in which the wet vapors, entering tangentially, cling to the sides of the cyclone and

water containing slurry discharges at the bottom, the gases and purer water vapor discharging up the stack. One common stack serves both dryers.

Figure 8 is a curve showing the size distribution of the heat dryer feed, or the froth flotation plant product. It is practically all minus 20-mesh material, 56 percent under 48 mesh and 15 percent through 200 mesh. This is a typical analysis under normal conditions, although in actual

practice the feed frequently varied in the direction of much greater percentages of minus 200 mesh.

Material and Heat Balance

Figure 9 is a material balance in diagrammatic form of the feed input distribution during the plant acceptance tests. Of 82.6 tph feed input at 25.2 percent surface moisture, the dried coal product at 5.7 percent moisture amounted to 75.6 percent of the feed. Nineteen and a half percent was evaporated as water vapor. The furnace consumed 3.9 percent, dust loss amounted to 0.02 percent, and slurry from the wet collector accounted for 0.98 percent of the feed.

The heat balance is shown in diagrammatic form in figure 10. Total heat consumption is 1678 Btu per lb of water evaporated, distributed as follows: 69 percent to evaporate the water; 8.08 percent to heat the coal, 13.55 percent is heat loss in the exhaust gases; conduction and radiation losses are 2.4 percent; 3.14 percent is used in heating the air coming in with the coal feed, and 3.83 percent is lost in heating the furnace.

A summary of pertinent data obtained during the plant's acceptance tests are shown in Table 2. Here it is indicated that 3,173,000 Btu were required to evaporate a ton of water. The final dust loss up the stack amounted to only 0.073 grains per cu ft. The wet scrubber slurry contained 860 lb per hour of the feed (dry basis) which was sent back to the washery for recirculation. Power consumed was 395 kw. Moisture in the dried coal product was 5-6 percent.

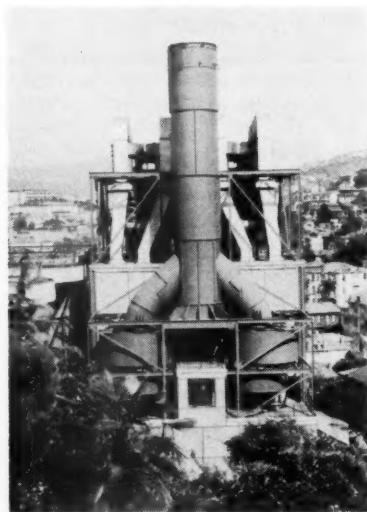


Fig. 7.—One common stack serves both dryers

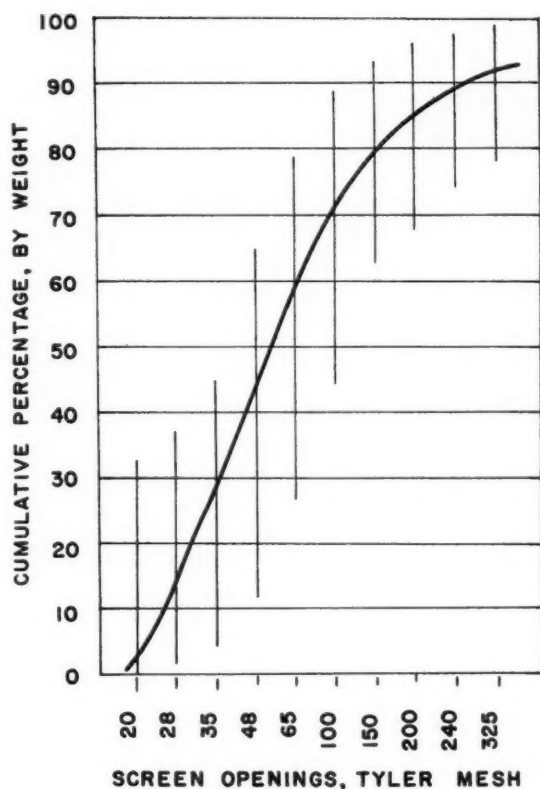


Fig. 8.—Size distribution curve of feed to the dryers. Fifty six percent is minus 48 mesh and 15 percent is minus 200 mesh

Actually it was entirely possible to produce a bone dry product, however it was determined that when the product moisture was reduced below five percent it became too dusty to handle at the loading point into bunkers or railroad cars. It is also believed that some hazard would result from possible spontaneous combustion if the moisture content was made less than five percent.

The above description of the Buttner dryer installation at Zonguldak attempts to describe the basic design of the plant, the processing involved and the results achieved. The plant did a remarkably good job on an extremely difficult feed and unquestionably proved to be a successful way of drying ultra fine coal.

Greater efficiency could be achieved in dust collection by more sophisticated equipment. Electrostatic precipitators are successfully being used in Europe in similar installations, but for the particular job at Zonguldak the equipment described was found satisfactory.

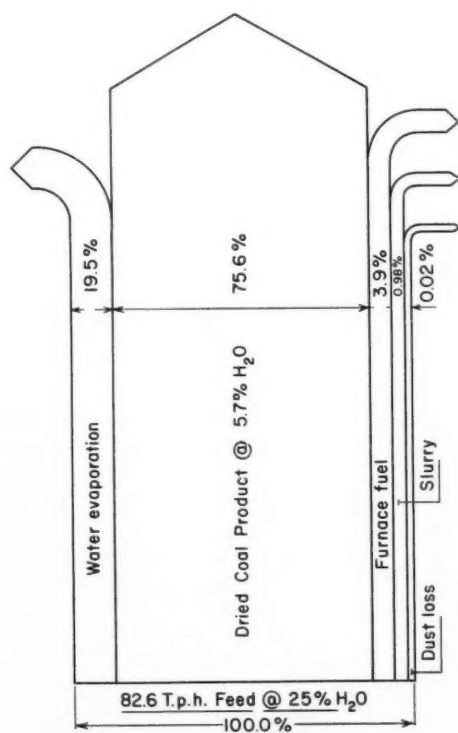


Fig. 9.—Material balance chart

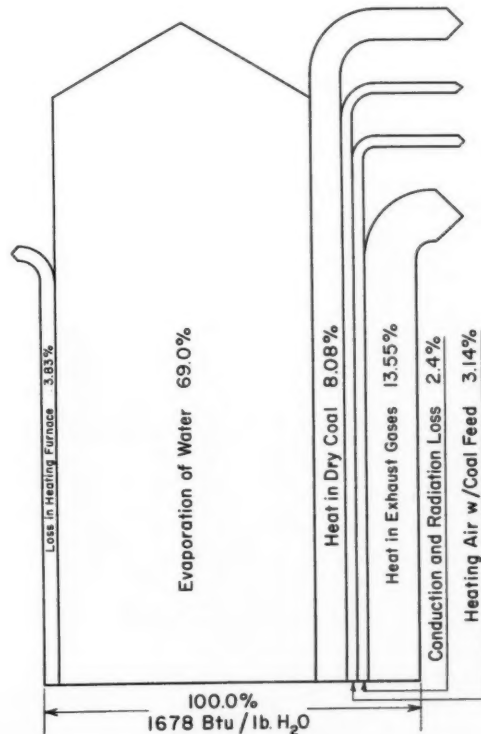


Fig. 10.—Heat balance chart

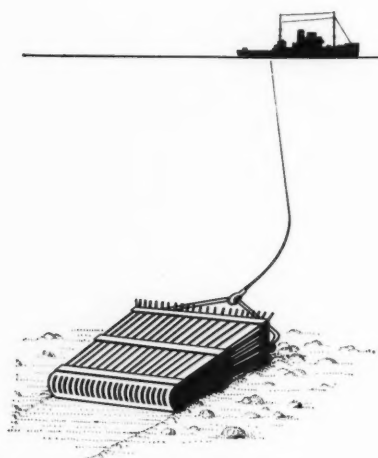


Fig. 1. A drag type of dredge could be used to mine nodules in water less than about 5000 ft deep, but this type of operation would not clean the sea floor efficiently

Economics of Deep-Sea Mining

By JOHN L. MERO
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Exploitation of manganese nodules on the ocean floor appears to be both technically and economically feasible

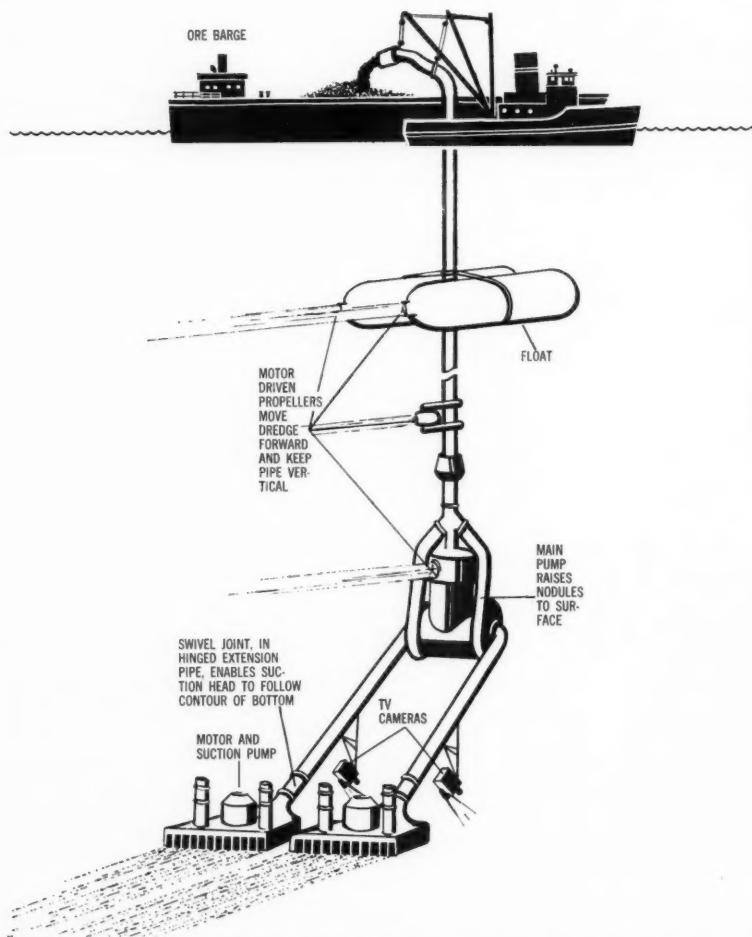


Fig. 2. Artist's conception of one design of a deep-sea hydraulic dredge. Impellers attached at regular intervals on the pipeline would propel the dredge through the water, and a stabilization float at the surface would provide vertical stability

AN article in the October 1960 issue of Mining Congress Journal described various sea-floor materials as potential mineral resources.¹ To call these materials mineral resources is to assume that they can be mined, processed, and marketed at a cost similar to or less than those from present sources. Whether the sea-floor mineral deposits actually can be mined at a profit or not remains to be seen, as no such operation has ever been tried. On paper, deep-sea mining appears to be technically and economically feasible. As manganese nodules are the most promising sea-floor sediment for future exploitation on a large-scale basis, this discussion will be oriented to the recovery of this material.

Drag Dredge Least Complicated

Probably the least complicated method of mining sea-floor nodules would be some form of deep-sea drag dredge. The equipment involved is simple, inexpensive, and has been used for almost 100 years to recover sediments from depths as great as 30,000 ft. Figure 1 illustrates the general set-up of a drag dredge operation. Figure 2a shows the present type of deep-sea drag dredge used by oceanographers mainly to recover hard rock samples from outcrops.

A drag dredging operation would require two floating vessels. The dredging ship, a 2000-ton ocean-going tugboat or salvage ship with a 2000-hp winch for dredging to 5000 ft, could be chartered to keep capital

costs down. This ship should have excellent maneuverability. It would contain living quarters for the crew of the mining operation. The ship's main generators could serve as a power source for the dredge winch since only a small fraction of the power output will be used for propulsion during mining operations. Although it would be advantageous to have a specially designed ship, existing vessels could be modified for the job at a cost of about \$1,000,000.

The second vessel, an ocean-going barge, would be large enough to store about 5000 tons of mined and cleaned nodules. This barge would carry equipment to separate the nodules from the debris dredged up, and a small propulsion unit to enable it to follow the dredging ship during mining operations. It would also have facilities for rapid transfer of mined material to a waiting transport vessel.

Dredge Bucket Would Have 13-Ton Capacity

The dredge bucket should be as large as possible, allowing for safe working conditions at sea. On a 2000-ton ship, the largest practicable size would be about 12 ft wide by 3 ft high by 20 ft long. This bucket would weigh about three tons and its load capacity, assuming a 65 percent filling efficiency and a 56 lb per cu ft bulk density of dredged material, would be about 13 tons per haul. If 25 percent of the material is assumed to be gangue, such as sharks' teeth, whale earbones, and fine sediments, about ten tons of nodules would be recovered per haul.

The bucket will be allowed to drop at a free-fall velocity to the sea floor; with proper hydrodynamic design, this should be as much as 600 fpm. A sonic pinger would be attached to the bucket so the operator would know when it reached bottom. The bucket would be dragged until it was filled and then would be retrieved. Television cameras are presently available that could be mounted on the bucket to help guide the operator filling it. The TV cable could be embedded in the core of the dredging cable to avoid the complications of a two-cable dredge line.

As the bucket surfaces it would be drawn up over a track on the back of the dredging ship and its load dumped into a hopper. From the hopper, the nodules would be fed into a pump and pipeline which would carry them to the storage barge. As the nodules are generally of low density and a nonabrasive character, transport by rubber pipeline should

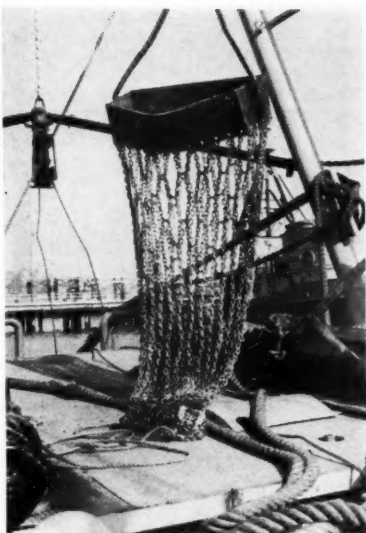


Fig. 2a. The present type of deep-sea drag dredge bucket is essentially the same as that used by the scientists of the Challenger Expedition almost 100 years ago. A fine-mesh cloth net is generally fitted inside the chain bag to retain small rocks. The dredge shown here is about eight ft long

involve no difficulties. On the storage barge the nodules would be separated from the gangue, crushed, and stored in hopper-type compartments designed to facilitate rapid transfer of the nodules to a transport vessel.

Operating Costs Listed

If we assume a 300 day working year and charter the dredging ship and storage barge, the cost of running a deep-sea dredging operation can be estimated as follows:

- | | |
|--|-----------|
| A) Fixed operational costs per year: | |
| 1) Chartered dredging ship at \$2500/day, 365 days/year | \$912,500 |
| 2) Storage barge, chartered at \$500/day, 365 days/year | 185,000 |
| 3) Depreciation and maintenance on equipment (sonic pingers, dredge buckets, cameras, depth recorders, crushers, etc.) | 320,000 |
| 4) Labor, supervision, and overhead | 667,500 |
| Total fixed operational costs per year \$2,085,000 | |
| B) Variable operational costs per year (Largely dependent on the depth of dredging): | |
| 1) Winch, at \$5200 per ton of capacity: Depreciation and maintenance at 40 percent per year of total cost; | |
| 2) Cable, replaced four times a year at full cost; and, | |
| 3) Power, figured at \$0.02 per hp-hour, operating 300 days per year, 20 hours per day. | |

Filling Bucket is Longest Part of Cycle

It is assumed that the mining operation will be shut down about 18

percent of the time due to bad weather, ore carrier delays, etc. In a 24-hour working day, four hours would be allowed, on the average, for equipment maintenance shutdowns. By using the above data and assuming an overall mechanical and electrical efficiency of the hoisting system of 65 percent (while maintaining a 2.5 safety factor on the cable) and a bucket dredging velocity of three fps, data were developed which indicated the production cost of dredging from various depths (see table 1). The total weight being hoisted will be a combination of the submerged weight of the load and dredge bucket and the drag exerted on the bucket and cable. A more detailed discussion of these forces and the power required to overcome them can be found in a report on the economics of mining and processing deep-sea nodules.²

Because the time it takes to fill the dredge bucket by dragging it along the bottom can be an appreciable part (over 70 percent in some cases) of the dredging cycle, concentrated deposits of the nodules can help decrease the production costs shown in table 2. There would be little detailed control over where the bucket lands in this method of dredging. However, deposits of manganese nodules are generally so vast in lateral extent that random cuts through a deposit could be made for years without one cut ever crossing the path of another.

Hydraulic Dredging is More Efficient Method

Any large-scale, efficient operation to mine sea-floor sediments with present technological means would require some form of a hydraulic dredge. Normally hydraulic dredges operate with a motor and a pump inside the hull of a vessel, with the pump near or just below the level of the water in which the vessel is floating.

In order to draw water and dredged sediments through the pump, it must develop a vacuum at its suction end. Hydraulic dredges of this design are, consequently, severely limited to the depth from which they can pump. Operating in the atmosphere, the maximum suction they could develop is atmospheric pressure or about 34 ft of water. Developing this vacuum, however, would cause the water at the suction end of the pump to boil.

In general, hydraulic dredges work with an effective suction head of about 25 ft of water. If we neglect fluid friction and assume a ten to one fluid-solids weight ratio in the

Depth of Dredging (Feet)	Cable Size (In.)	Lowering Velocity (Ft/Min)	Raising Velocity (Ft/Min)	Total Drag Force (Tons)	Steady State Wt. Hoisted ⁽²⁾ (Tons)	Average Power Required (Hp)	Cycle Time ⁽³⁾ (Min)	Rate of Production (Tons/Day)	Operating Costs (\$/year)	Cost of Production (\$/ton)
1,000	1	300	400	0.985	10.91	407	20.08	598	2,167,200	12.10
1,000	1	300	750	3.465	13.39	935	18.66	643	2,214,700	11.50
1,000	1	300	1000	6.175	16.10	1502	18.23	658	2,265,700	11.50
3,000	1	300	400	1.000	11.61	434	33.05	363	2,172,600	20.00
3,000	1	300	750	3.517	14.13	990	28.80	416	2,227,600	17.85
3,000	1-1/8	300	1000	6.258	17.16	1600	27.80	431	2,285,380	17.70
3,000	1	600	400	1.000	11.61	434	28.05	427	2,177,600	17.00
3,000	1	600	750	3.517	14.13	990	23.80	505	2,227,600	14.70
3,000	1-1/8	600	1000	6.258	17.16	1600	22.50	534	2,285,380	14.30
5,000	1	300	400	1.115	12.43	465	46.02	261	2,188,400	28.00
5,000	1-1/8	300	750	3.568	15.34	1072	38.94	308	2,247,800	24.40
5,000	1-1/4	300	1000	6.360	18.43	1720	36.77	326	2,311,300	23.60
5,000	1	600	400	1.115	12.43	465	37.69	318	2,188,400	23.00
5,000	1-1/8	600	750	3.568	15.34	1072	30.61	392	2,247,800	19.10
5,000	1-1/4	600	1000	6.360	18.43	1720	28.44	421	2,311,300	18.30
5,000	1-1/2	600	1500	14.290	27.77	3880	26.27	456	2,520,000	18.40
5,000	1-3/4	600	2000	25.420	40.31	7520	25.19	476	2,867,500	20.50
8,000	1-1/8	300	750	3.605	16.70	1168	55.10	218	2,371,180	32.10
8,000	1-1/8	600	750	3.605	16.70	1168	41.78	287	2,371,180	27.60
10,000	1-1/4	300	750	3.696	18.70	1308	64.26	187	2,304,300	41.20
10,000	1-1/4	600	750	3.696	18.70	1308	47.60	252	2,304,300	30.60

(1) With equipment and working conditions as outlined in this paper and assumptions of a nodule concentration on the sea floor of one pound of nodules per square foot and a dredge pick-up efficiency of 80 percent.

(2) Sum of drag forces plus weight of bucket and load in seawater.

(3) Time required for complete dredge cycle including lowering, loading, raising, and unloading.

Table 1. Nodule production rates and costs using the deep-sea drag dredge

pipeline, the maximum depth from which such a dredge could lift sediments, assuming a uniform density of the water at all depths, would be about 250 ft. Of course, the fluid-solids ratio could be increased and the dredge would work in greater depths. However, power is being expended to overcome fluid friction as well as lift the solids in the pipeline, and the point would soon be reached at which power costs far exceeded the value of the dredged material. Unless the depth of water is less than sev-

eral hundred feet, therefore, the pump on any deep-sea hydraulic dredge must be submerged.

Major Components Include Pump and Pipeline

Although it must be submerged, the pump need not be operated near the sea floor. The factors controlling the location of the pump in relation to the surface of the ocean will be the fluid-solids ratio of the material in the pipeline and the fluid velocity

at which the dredge is operated. It is advantageous from a number of standpoints to operate with the pump as close to the surface as possible and the calculations, therefore, will assume such a position.

The major components of a deep-sea hydraulic dredge are a pipeline, pump and motor, suction heads, and a float. Although the weight of the dredge could be suspended from a floating vessel, such a system would be somewhat disadvantageous. Vertical oscillations of the vessel due to

Depth of Dredging (Feet)	Lowering Velocity (Ft/Min)	Raising Velocity (Ft/Min)	Production Rates (Tons/Day) at Various Nodule Concentrations				Production Costs (\$/Ton) at Various Nodule Concentrations			
			0.5#/Ft ²	2#/Ft ²	5#/Ft ²	10#/Ft ²	0.5#/Ft ²	2#/Ft ²	5#/Ft ²	10#/Ft ²
1,000	300	750	396	935	1157	1460	18.60	7.90	6.40	5.05
3,000	300	750	298	521	614	655	24.90	14.25	12.10	11.30
3,000	600	750	349	667	825	900	21.30	11.10	9.00	8.25
5,000	300	750	238	362	404	436	31.50	20.70	18.60	17.20
5,000	600	1000	300	530	626	666	25.70	14.55	12.30	11.55
8,000	600	750	225	333	369	383	35.10	23.70	21.40	20.60

Table 2. Drag dredge production rates and costs at various sea-floor nodule concentrations (other operating conditions same as for Table 1)

wave motions would be transmitted to the dredge introducing alternating stresses in the pipeline that might cause it to fail. Also, with such a system, the vessel and dredge would be extremely vulnerable in case of a sudden storm. The dredge, therefore, should be supported by floats which are an integral part of it.

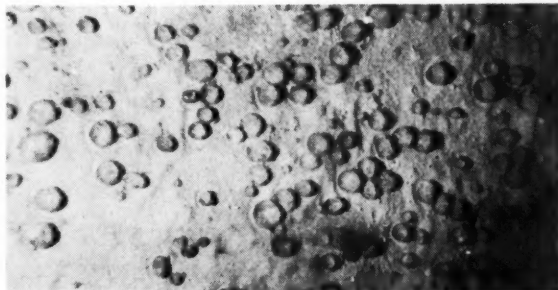
As shown in figure 2, the main float tank is submerged below the turbulent surface layer of water, so that no vertical wave motions will be transmitted to the dredge. A stabilization float is provided at the surface to keep the dredge afloat. As 99 percent of the weight is supported by the main float, no vertical oscillations of wave motions acting on the stabilization float would be transmitted to the dredge as a whole.

The pump and motor of this system would be in the main float, which is over-sized and ballasted with sea-water to give the dredge proper trim. Should there be either a motor or pump failure, the ballast can be pumped out causing the float to rise to the surface. A manhole at the top would allow easy access for repairs. In case of a sudden pump or motor failure, back flow valves along the pipeline would automatically open to prevent the falling nodules so as to prevent jamming.

Depth and Nodule Size Principle Design Considerations

The calculations included here are for a dredge designed to operate in 10,000 ft of water, but the cost esti-

Manganese nodules on the Atlantic Ocean floor about 200 miles southeast of Bermuda. The average diameter of these spherically-shaped nodules is about two in., the maximum size being about three in. The concentration is about three lb of nodules per sq ft of sea floor



mates are listed so that they can be extrapolated to other operating depths within the strength limitations of the materials of construction.

Although the hydraulic dredge would be designed to mine a particular deposit of nodules, its application would be general in all deposits in which nodule diameter did not exceed about half the pipeline diameter. The depth of the deposit and

the size of the nodules are the prime design considerations. Fortunately, most of the sea-floor photographs showing manganese nodules indicate that the nodules within a specific deposit have a relatively uniform shape and size.

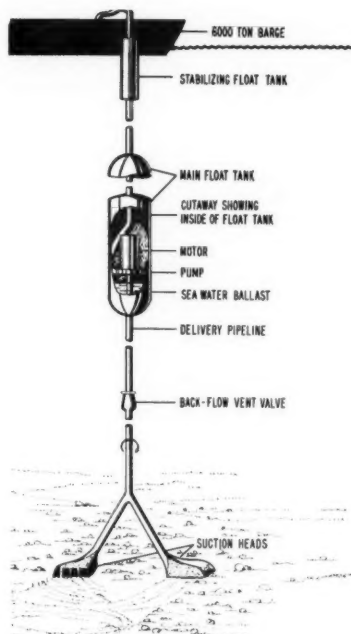


Fig. 3. Vertical-float dredge, with pump and motor near the surface, would rotate around its central axis. Since the operator would have little control over the position of the dredge heads, the method would be less efficient than the hydraulic dredge in Figure 2

moving too much of the sediments.

The main advantage of the dredge described here is that no major piece of electrical equipment is submerged other than the television cameras mounted on the dredge heads. Although the motor and pump would be operating submerged to about 10 percent of the depth of dredging, they would be inside an air-pressurized float tank. A conventional motor could be used, and the pump would not require any radical additional design over conventional dredge pumps.

Television cameras would be mounted on the dredge heads to watch the mining operation at the sea floor and to give the operator information as to the dredging efficiency. As the dredge would be operating like a vacuum cleaner, drawing all loose sediments into the pipeline, no clouds of sediment would be raised to obscure the view. The operator would have gross control of the location of the dredge heads on the sea floor. The television cameras, thus, would be of prime importance in controlling the dredging operation so that reasonably close parallel cuts could be made through a deposit without excessive overlap.

The design considerations of the dredge will be:

Depth of operation: 10,000 ft

Max. diam. of nodules to be dredged: 6 in.

Diameter of pipeline: 20 in. ID

Velocity of fluid flow in pipeline: 15 fps

Fluid-solids ratio in pipeline: 10-1 by weight

Percent of nodules in fluid: 5% by weight (assuming 50 percent of the solids dredged will be gangue materials)

Specific gravity of solids in fluid: 2.1

Foul weather downtime: 20% of total

Equipment downtime: 16% of total

Production Rate of 4200-tpd Attainable

Pumping at a rate of 2320 lb of fluid per second, of which five percent is nodules, would result in a production rate of nodules of about 4180 tons per 20-hour working day, or 1,220,000 tons per 292-day working year. A dredge rotating at one rpm, having twin suction arms with eight-ft mouths operating about 100 ft apart, would be used for this operation. Working in a nodule deposit with a concentration of about three lb per sq ft at a pick-up efficiency of 50 percent, this dredge would be able to make a 4180-tpd production rate without difficulty.

Capital and Production Costs

Production costs are calculated so that they can be applied to any depth of dredging with the hydraulic dredge. The operating costs listed below include depreciation, overhauling, major repairs, painting, interest, taxes, insurance, and other incidental ownership expense:

A) Costs independent of the dredging depth

Item	Capital Cost	Operating Cost Per/Year
Storage barge, 15,000-ton used hull	\$800,000	\$280,000
Barge auxiliary equipment	400,000	160,000
Suction heads	200,000	200,000
TV cameras, cables, and controls	200,000	75,000
Miscellaneous equipment	450,000	150,000
Design	300,000	—
Overhead	—	300,000
Dredge construction costs	500,000	—
Labor for mining operation	—	365,000
Chartered control ship, 3000-ton	—	1,095,000
Modifications to control ship	1,500,000	—
Capital costs independent of dredging depth	\$4,350,000	—
Yearly operating costs		\$2,625,000

B) Costs dependent on the dredging depth

Item	Capital Cost (\$/ft of Water)	Operating Cost (\$/year/ft)
Pipeline	\$40.00	\$20.00
Floats	20.00	10.00
Pump	5.00	5.00
Motor (\$80/hp) (0.778 hp/ft)	62.40	23.70
Power Cable (\$20/ft) (10% of Depth)	2.00	1.00
Instrumentation	10.00	10.00
Miscellaneous	20.00	10.00
Capital costs dependent on depth	\$159.40/ft	
Yearly operational costs dependent on dredging depth		\$79.70/ft

C) Power costs—Power will be taken for the dredge motor from propulsion motors of the ship. While dredging, little power will be required for propulsion. A total of about 10,000 hp should be available. If the ship's propulsion system cannot supply this, an auxiliary motor-generator must be installed. With the design considerations listed and using standard friction factors and hydraulic calculations found in fluid mechanics texts² and assuming a 75 percent overall efficiency, 0.778 hp per ft of depth is needed to power this dredge. The power cost can be calculated thus: (\$0.02/hp/hr) (5840 hrs/yr) (0.778 hp/ft of depth) = \$91.00/ft of depth/yr.

Thus mining costs for deep-sea hydraulic dredging, assuming a production rate of 1.22 million tons per year, could be expected to be:

$$\frac{\$2,625,000}{1,220,000 \text{ tons}} + \frac{(\$79.70 + \$91.00) d}{1,220,000 \text{ tons}} = \$ (2.15 + 0.00014 d) / \text{ton},$$

where *d* is the depth of dredging in feet. From 10,000 ft, therefore, the production cost could be expected to be $2.15 + 0.00014 (10,000) = \3.55 per ton of nodules recovered.

The rate of production for a deep-sea hydraulic dredge is a function of the size of the pipeline, velocity of fluid flow in it, and the fluid-solids ratio and is independent of the dredging depth. The production costs for a given set of parameters, therefore, can be extrapolated to various depths to obtain an estimate of the production costs. Production costs, capital costs, and other statistics for dredging from various depths of water are listed in table 3. The statistics apply for a dredge with design parameters as outlined herein.

The dredge in figure 3 and described in this article would not allow very efficient cleaning of the sea floor. If it is expedient to do an efficient (continued on page 68)

Depth (Feet)	Horsepower Required (Hp)	Equipment* Capital Cost (\$)	Depth-Dependent Equip. Operating Costs Per Year (\$/Year)	Power Costs At \$0.02/Hp-Hr (\$/Year)	Fixed Operational Costs/Year (\$/Year)	Total Oper. Costs/Year (\$/Year)	Production Cost (P.R.=1,220,000 tons/yr) (\$/ton of nodules)
1,000	778	4,509,400	79,700	91,000	2,625,000	2,795,700	2.29
2,000	1,560	4,668,800	159,400	182,000	"	2,966,400	2.43
3,000	2,330	4,828,200	239,000	273,000	"	3,137,100	2.57
4,000	3,110	4,987,600	318,800	364,000	"	3,307,800	2.71
5,000	3,890	5,147,000	398,500	455,000	"	3,478,500	2.85
6,000	4,670	5,306,400	478,200	546,000	"	3,649,200	2.99
7,000	5,450	5,465,800	557,900	637,000	"	3,819,900	3.12
8,000	6,220	5,625,200	637,600	728,000	"	3,990,600	3.27
9,000	7,000	5,784,600	717,300	819,000	"	4,161,300	3.41
10,000	7,780	5,944,000	797,000	910,000	"	4,332,000	3.55
12,000	9,340	6,262,800	956,400	1,092,000	"	4,673,400	3.83
14,000	10,890	6,581,600	1,115,800	1,274,000	"	5,014,800	4.11
15,000	11,670	6,741,000	1,195,500	1,365,000	"	5,185,500	4.25
16,000	12,450	6,900,400	1,275,200	1,456,000	"	5,356,200	4.40
18,000	14,000	7,219,200	1,434,600	1,638,000	"	5,697,600	4.66
20,000	15,560	7,538,000	1,594,000	1,820,000	"	6,039,000	4.95

*Assuming a chartered control ship

Table 3. Nodule production cost estimates by hydraulic dredging from various depths

Beneficiation of Oxidized Iron Ores With Production of Concentrates Containing Metallic Iron

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and

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PRODUCTION of a high-quality concentrate with a low silica content is one of the most pressing problems in the beneficiation of limonite ores. All hitherto proposed methods did not yield high-quality concentrates, and were neither sufficiently productive nor economical. The authors propose a technologically cor-

rect solution of the problem. Nonetheless, the system proposed, which includes several stages of ore crushing, must be tested in a pilot plant in order to obtain data for thorough economic analysis. The results of this test will determine the commercial value of the method.

Many Soviet iron ores (iron quartz-

ite of Krivoi Rog and KMA, limonites of Lisakov, Ayatsk, Kerch, and others) cannot be efficiently treated by gravity and magnetic beneficiation methods of today because of thin oxidized ore impregnations, and because of the large-scale production and high quality requirements placed upon the concentrates.

Ore	Composition of charge, %		Size, mm		Duration of roasting, min*	Composition of roasted lumps		Degree of reduction $\frac{Fe_m}{Fe_t}$
	Ore	Anthracite	Ore	Anthracite		Total iron (Fe_t)	Metallic iron (Fe_m)	
Lisakov	85	15	0-0.15	0-0.074	30	54.96	39.96	72.7
Kerch (brown variety)	85	15	0-0.25	0-0.25	40	59.00	50.76	86.0
Akkerman	80	20	0-0.25	0-0.25	40	34.58	29.55	85.5
Slime from washed Akkerman ore	85	15	0-0.5	0-0.25	30	29.2	20.90	71.5

Table 1. Extraction and roasting of lumps of Kerch, Lisakov and Akkerman ores

*Roasting temperature 1,200° C.

Beneficiation of oxidized ores by the magnetizing roast method involves high capital investment and operating expenditures, which result from enormous fuel consumption and low productivity of rotating furnaces used in the process. Moreover, the Fe content of limonite concentrate obtained from a magnetizing roast process is usually less than 53 to 55 percent, while the tailings contain more than 22 to 24 percent Fe. This is caused primarily by the presence in the ore of substantial quantities of siliceous iron-bearing minerals, such as nontronite, chlorite, chamoisite and others, which acquire magnetic properties when roasted.

Flotation of iron oxide ores yields excellent technological results with comparatively small operating and capital expenditures. Engineering economic computations at the Mekhanobr Institute show that flotation at the Krivoi Rog Mining and Beneficiation Combine requires 40 percent less capital investment than the magnetizing roast process. Furthermore with flotation, costs are 13 to 17 percent less than with the magnetizing roast process. However, flotation of complex limonite ores meets with considerable difficulties.

Lumped Ore Is Given Reducing Roast

In 1956, the authors experimented with the lumping of iron ore concentrates which were partly reduced to metallic iron in the process. The investigations showed that it is possible to obtain solid lumps containing 60 to 70 percent metallic iron from concentrates of the KMA, YuGOK and Olenegorsk beneficiation plants.¹ The

¹ Kontorovich, G. I., Yarkho, N. A. and Reytarovskaya, L. A., *Stal' (Steel)*, 1959, No. 11.

Products	Yield, %	Composition, %		Recovery, %	
		Composition of roasted lumps	Degree of reduction	Total iron	Metallic iron
Magnetic,	46.3	93.1	84.8	78.6	100.0
Non-magnetic	53.7	22.0	-	21.4	-
Roasted lumps	100.0	54.9	39.2	100.0	100.0
Lisakov ore,	-	40.6	-	-	-
Magnetic,	63.5	92.5	77.9	96.9	99.5
Non-magnetic	36.5	5.3	0.6	3.1	0.5
Roasted lumps	100.0	60.8	49.7	100.0	100.0
Kerch ore,	-	39.8	-	-	-
Magnetic,	37.0	89.2	83.2	94.3	100.0
Non-magnetic	63.0	3.1	-	5.7	-
Roasted lumps	100.0	35.0	30.7	100.0	100.0
Akkerman ore,	-	30.0	-	-	-
Magnetic	33.2	70.0	65.2	82.2	100.0
Non-magnetic	66.8	7.5	-	17.7	-
Roasted lumps	100.0	28.2	21.6	100.0	100.0
Slime from washed Akkerman ore,	-	23.3	-	-	-

¹Size of material used for magnetic separation—0.074 mm.

Table 2. Magnetic separation of roasted lumps

lumps were given a 20 to 30 minute solidifying roast in a Silit furnace at a temperature of 1100 to 1250°C. (2012 to 2282°F). The charge consisted of 80 to 85 percent concentrate, 15 to 20 percent anthracite (0 to 0.5 mm. in size), and 1 percent calcium chloride in solution.

Research on the beneficiation of oxidized iron ores aiming at the pro-

duction of a concentrate containing metallic iron was initiated in 1957.² The raw materials were oxidized quartzite ore from the Krivoi Rog, limonite from the Akkerman, Lisakov and Kerch deposits, and slime from washed Akkerman ores containing 20 to 24 percent iron.

² Patent Certificate No. 622312/22.

Ore	Products	Preliminary roasting of ore at 600-700° C						Preliminary roasting of lumps at 1,200° C							
		Size of material, mm	Yield, %	Composition, %			Fe recovery, %	Yield, %	Composition, %					Degree of reduction $\frac{Fe_m}{Fe_0}$	Recovery of total iron
				Iron	SiO ₂	Al ₂ O ₃			Total iron (Fe _T)	Metallic iron (Fe _m)	SiO ₂	Al ₂ O ₃			
Kerch	Concentrate ..	-	61.5	53.2	11.5	5.0	74.8	63.5	92.5	77.9	3.2	1.6	84.3	96.9	
	Tailings	-	38.5	28.5	-	-	25.2	36.5	5.3	0.6	-	-	-	3.1	
	Roasted ore ..	0-0.2	100.0	43.7	-	-	100.0	-	-	-	-	-	-	-	
	Lumps	-	-	-	-	-	-	100.0	60.8	49.7	-	-	-	100.0	
	Crude ore	-	-	38.0	18.2	6.3	-	-	39.8	-	-	-	-	-	
Akkerman	Concentrate ..	-	66.7	54.5	15.6	2.2	82.0	37.0	89.2	83.2	3.3	1.6	94.4	94.3	
	Tailings	-	33.3	24.0	-	-	18.0	63.0	3.1	-	-	-	-	5.7	
	Roasted ore ..	0-0.074	100.0	44.3	-	-	100.0	-	-	-	-	-	-	-	
	Lumps	-	-	-	-	-	-	100.0	35.0	30.7	-	-	-	100.0	
	Crude ore	-	-	37.5	16.4	9.9	-	-	30.0	-	28.0	9.3	-	-	

Table 3. Beneficiation indices for Kerch and Akkerman ores [two methods of beneficiation]

Table 1 gives the optimum parameters of lumping and roasting; table 2 the results of low-field magnetic separation of roasted lumps from Kerch, Lisakov and Akkerman ores and slimes from washed Akkerman ore.

Tables 1 and 2 show that by subjecting the lumps to a preliminary, high temperature reducing roast it is possible to obtain concentrates containing 90 to 93 percent total iron (including 78 to 85 percent metallic iron) with an Fe recovery of 79 to 97 percent. Concentrates obtained from slimes of washed Akkerman ore contained 70 percent total iron, including 65 percent metallic iron, and the Fe recovery was 82 percent. In the magnetic separation of lumps made from naturally alloyed (iron-chrome-nickel) Akkerman ore and slimes of washed Akkerman ore, the nickel recovery in the concentrate was 95 percent and that of chrome was 28 to 30 percent.

Effect of Temperature Variations

Table 3 gives the results of beneficiating Kerch and Akkerman ores according to two procedures: with a preliminary magnetizing roast at 600 to 700°C (1112 to 1292°F), and with preliminary high temperature roasting of coal-ore lumps at 1200°C (2192°F).

Concentrates obtained from roasted coal-ore lumps contain over 90 percent iron and three to four percent silica, while the tailings contain from three to five percent iron. The low iron content in the tailings results from the separation of Fe from iron silicate minerals (nontronite, chlorite, chamoisite, etc.) at the high temperatures used in roasting these ores (1100 to 1200°C).

Roasting at 1100°C showed that the mean rate of reduction of lumped ore is five to seven times higher than that of unlumped ore. This is explained by the close contact of ore and fuel particles and the more favorable conditions for iron reduction.

The principal advantage of high temperature roasting of coal-bearing ore lumps is that it can be conducted on a large scale in sintering belt furnaces. This explains the obvious advantage of the method described above over the American RN-method³ employing rotary kilns, in which the output of a 150 ft by 8³/₄ ft diam kiln, as an example, is only 175 tpd of crude ore.

Conclusions

1. High temperature roasting of iron ores makes it possible to obtain concentrates containing over 90 percent iron (including 85 to 90 percent metallic iron) with a high Fe recovery. Effective beneficiating of limonite ores, which are not readily beneficiated, is also possible by this method.

2. When treating naturally alloyed iron-nickel-chrome ores, this method makes it possible to recover nearly all of the nickel in the concentrate and to remove most of the chrome, which may complicate refining operations of chrome-nickel pig iron made from

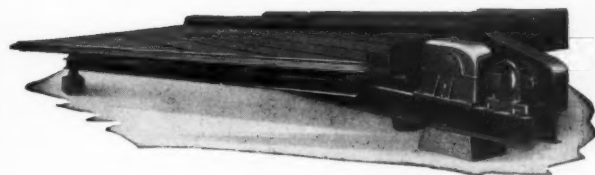
these ores.

3. Lumping increases the thermal conductivity of the charge and, consequently, the rate of reduction increases five to seven fold.

4. The higher cost of the concentrate obtained after the thermal treatment of coal-ore lumps will be offset by the savings in coke and increased productivity of the metallurgical furnaces.

5. Concentrates may be lumped by any known method: briquetting or sintering in an inert or reducing medium.

6. Future investigations should center around technology of roasting coal-ore lumps in agglomeration pans.



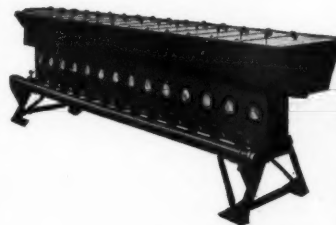
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³ Stewart, Work N. K., *Journal of Metals*, No. 7, July 1959.

Interconnection of Hoist and Crowd Controls—

By A. M. VANCE

Mining Industry Engineer
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A Step Toward Shovel Automation

LIKE every other industry the open pit mining industry has the same problem of trying to obtain more output with the same initial cost and operating expense. This means more ore is to be loaded, more coal is to be loaded, or more overburden is to be removed per day with the same excavating equipment. Therefore, the aim of the industry is to develop and place in service more efficient methods of operating shovels and draglines.

Coal reserves with only 40 ft of overburden to 4 ft of coal, or a 10 to 1 ratio, are being depleted. Ratios of 12, 15, and 20 to 1 are common in today's stripping operations. Therefore, with the increase in overburden to be handled, more new economical open pit mining equipment must be developed to enable the coal strip mining companies to maintain a profit.

Normally to move more overburden in a given time, larger stripping shovels are required. In other words the amount of overburden that can be moved in a given time would seem to be directly proportional to the shovel size or the dollars invested. However, a 45-cu yd shovel will cost approximately one million dollars and will move about 2000 yards of overburden per hour. A 60 cu yd shovel will cost approximately three million dollars and will move about 3000 yd per hour. With these figures, therefore, other means of improving production with the same size shovels must be investigated.

Television Helps Shovel Runners

An engineer employed by one of the larger open pit coal producing companies mentioned that the difference in efficiency (co-ordinating ability) between two stripping shovel operators might be as much as 40 percent. This is much the same as playing golf. Compare two men with the same years of experience playing

the game. One will have the co-ordinating ability and finesse to place that little white ball where he wants it and the other will have more trouble and a higher score. This difference in score between golfers can be adjusted by means of a handicap, however, a difference in operators presents another type of handicap to the industry. Therefore, it is necessary to reduce this difference between operators by supplying a simpler, easier co-ordinated, less fatiguing type of apparatus to allow an operator on a given shovel to move more overburden, load more coal, or load more ore within a fixed time.

One aid that has been investigated

is the use of television to determine when the bucket is full. Several problems of where to mount the TV camera have been investigated. Mounting the camera on the boom, high wall, or on the dipper stick all presented definite individual problems for each installation. The biggest obstacle was how to evaluate the operator's ability to change from looking at a small TV screen to the large actual bucket and then make a co-ordinated decision as to what changes to make in the movement. This led to experimental work on the stereoscopic vision (or depth perception) of each operator.

A study was made to find the length



As stripping equipment has grown in size, controls had to be improved also; a big step forward in the evolution of controls was the addition of magnetic amplification. Such a system was employed on this 45-yd shovel to provide a means of obtaining more peak digging power with the same rotating equipment

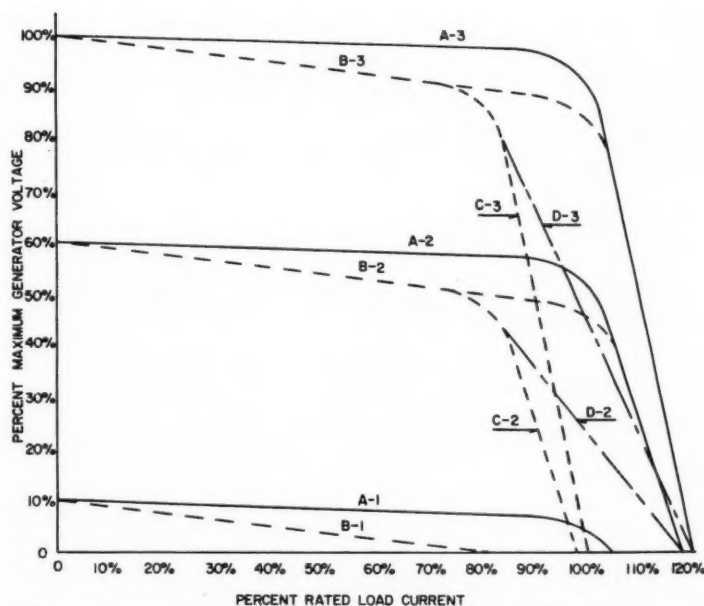


Fig. 1. Typical volt-ampere curves for system in which an amplifying exciter is inserted between the magnetic amplifier and the d-c generator fields

of time required for an operator to react to the bucket entering the bank and to keeping the bucket under constant control. That is, to determine the length of time required for the human eye to recognize a given change in conditions and the magnitude of the change. The results indicated that an operator with 20/20 vision in each eye (monocular vision) may still have poor stereoscopic vision. He will operate under a handicap by actually focusing with one eye using monocular clues such as a form, shape, or shadow. Future studies into changes in the color of the bucket with respect to the bank might contribute to the operator's efficiency.

Improvements in Control Techniques

Small loading size shovels have been supplied with magnetic type control and larger machines, including stripping shovels and draglines, have been supplied with rotating type regulators. New control techniques for improved production have been introduced in recent years. Future new improvements in control are needed and are being developed.

The first step in this evolution of control improvement was the addition of the Magamp magnetic amplifier to amplify the current signal into the rotating regulator. This system was employed on a large 45-cu yd shovel to provide a means of obtaining more peak power with the same equipment to providing more current

forcing. The d-c rotating equipment peak power could be utilized as the current signal, and could be amplified to provide the equipment with greater dynamic response. This response provided greater protection to the electrical equipment and to the hoist cable, but the increase in production was a small percent of that desired. The primary regulator was still a rotating type regulator which required large power sensing and stabilizing circuits.

The next step was the introduction of the Magamp as the primary regulator. On small loader size shovels the Magamp was used directly to excite the field of the d-c generators. This provided a control system with low power inputs for future system changes. The first use of Magamp as the basic regulator was on this same 45-cu yd shovel. However, for economic reasons, because of the size of the generators and because of its natural reversing capabilities, an amplifying exciter was inserted between the Magamp and the d-c generator fields. This combination gives the maximum versatility for easy adjustability of the system to suit different digging conditions.

As the load in the motor generator loop is increased, the system will have an inherent voltage droop from no load to the point at which the current limit overcomes the voltage regulator as shown by the solid line curves (A-1) (A-2) (A-3) on figure 1. As the load current increases, the armature circuit IR drop will exceed a current

limit bias voltage allowing a portion of the load current to flow in the Magamp current limit field. This field is connected to oppose the control field and rapidly decrease the Magamp output to decrease the generator voltage and armature current. The gain of the current limit circuit is sufficiently high to effectively limit current over-shoots on the most rugged stall and plugging operations.

Adjustments of the current limit allow easy modification of the generator performance. By changing one resistor a portion of the load current is allowed to flow in the Magamp current limit field resulting in a change of the no load to full load slope of the volt ampere characteristics as indicated by the dash lines, curves (B-1) (B-2) (B-3) (figure 1). By decreasing the value of one resistor with all other resistance values remaining constant, current limit starts to operate at a lower value of load current as shown by the dotted curve (C-2) (C-3). By increasing another resistor with all other values of resistance remaining constant, the stall torque will be increased by a change in the slope of the volt ampere curve as shown by curves (D-2) (D-3).

Performance curves such as (A-1) (A-2) (A-3) could be used in digging compact uniform material such as sand where high speeds and torques are desired with a minimum of stalling. A combination of the other curves is necessary in heavy rough digging where reduced torques at high speeds are desired to limit shock loading on the shovel structure should the drive suddenly stall.

On the latest loader size shovels a further improved control system is being employed. This control is a unique all-static control. The first stage of this control consists of a Magamp in conjunction with transistors to provide a firing circuit for the second stage amplifier. The Magamp is used as a computer to integrate the various signals such as the operator's signal from the stepless master switch, the voltage or current feedback (depending on hoist, drag, crowd, or swing motions) and the current limit signal to produce an output for the desired production and protection of the electrical equipment. The Magamp in conjunction with transistors and other semiconductor control units provides a positive pulsed firing circuit to trigger the second stage static power amplifiers for all conditions of master switch output and equipment protection.

The second stage of the control is a

static power amplifier which consists principally of the Tristor controlled rectifiers referred to by AIEE standards as a semiconductor PNP switch. This semiconductor in conjunction with protective diodes is assembled on a heat sink. A combination of these assemblies will provide the control system with a very high gain push-pull power amplifier. Eight such assemblies will provide the necessary excitation power and control of the generators on the present size loader shovels. Larger capacity Tristor controlled rectifiers have been developed and are being placed in production to extend the range of their application to stripper size shovels.

Characteristics (figure 2) of the Tristor controlled rectifiers are such that they will block an applied voltage until it exceeds the breakover voltage which is shown as approximately 400 volts. This breakover voltage can be reduced by applying a small input current I_b into the base or gate lead of the semiconductor. With a gate current of 40 milliamperes the voltage drop in the Tristor controlled rectifier will be one volt with the remainder of the applied voltage impressed across the external load resistance.

Since the Magamp is used as a voltage regulator on the hoist, drag, or crowd motions and as a current regulator on the swing motion it serves as the computer to determine the value of base or gate current to the Tristor switch to reduce the breakover voltage and allow it to conduct power to the load. By switching the 60 cycle a-c power "off" and "on" as much as 120 times a second as dictated by the Magamp computer, and at the same time rectifying the power, the Magamp-Tristor control provides a wide range of adjustable voltage to the field of a d-c generator.

The switching time of the Tristor static amplifier is approximately two microseconds, therefore it interposes a negligible time delay into the control system. The amplifier also has a very high gain, therefore, a very small gate or base firing signal is all that is required from the first stage Magamp. This means a very small Magamp is all that is necessary for the first computer stage. Since there is negligible time delay in the Magamp and Tristor amplifiers, the regulating system has only one time delay—that of the generator field. This eliminates the stability problems and allows simplification of the control circuits. All of these new develop-

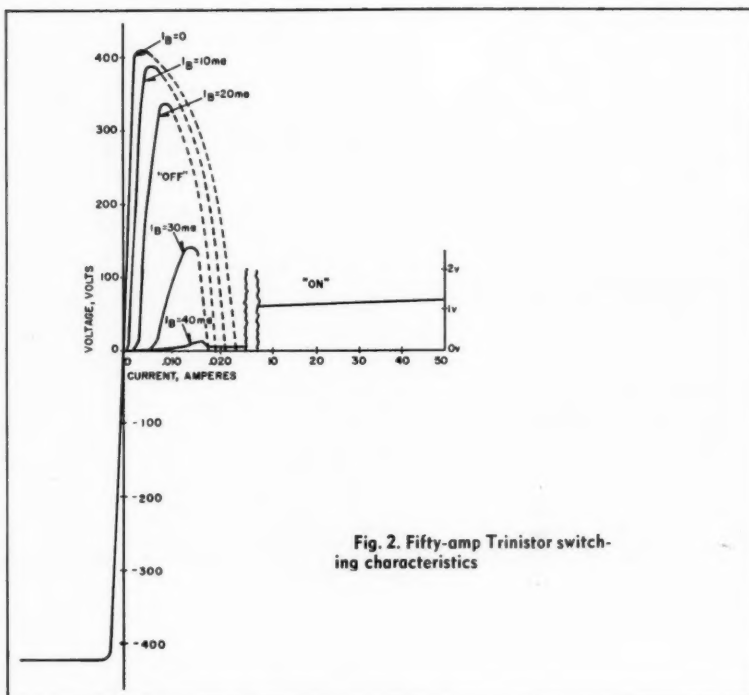
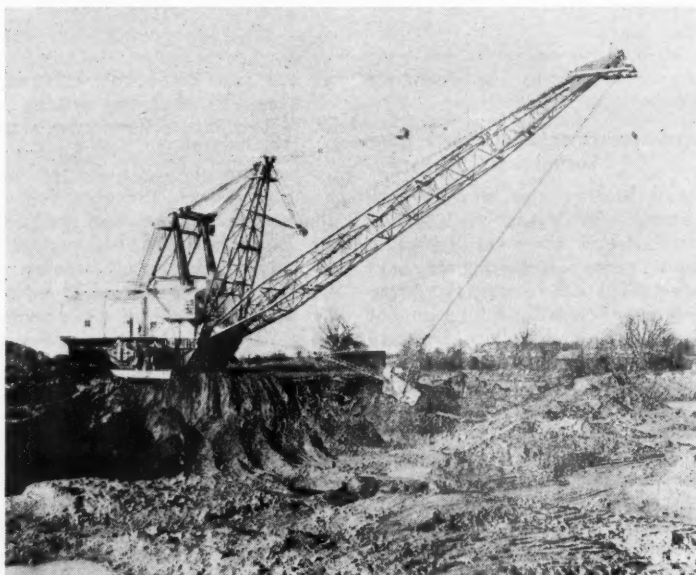


Fig. 2. Fifty-amp Tristor switching characteristics

ments have set the stage for more automation in shovel operation.

The first step in this direction is in tying two functions together in the same master switch handle similar to the joy stick in early aircraft. The International Minerals & Chemical Corp., in their Florida phosphate operation, have used this system on a 650 B dragline. They developed a

special master switch with a ball joint so that it could operate in all directions. Then they added to this handle an actuating mechanism to operate two rheostats at right angles to each other. The forward and backward movement of the master switch handle will indicate a raise or lower signal to the hoist motion. With a right and left movement of the master switch



Two functions, hoist and swing, are tied together in same master switch in a dragline used in Florida phosphate mining



New regulators are a feature of wheel excavators placed in service by United Electric Coal Companies and Peabody Coal Co.

handle the swing motion is signaled to move to the right or left. Any other directional movement will give a signal to both the hoist and swing motions. This is a deviation from the standard practice of two hand-operated master switches and one foot-pedal operated master switch and is an aid to newer operators.

With the use of the Magamp as a primary regulator lower power, sensing devices such as master switch,

stabilizing circuits, etc., are required. Also more isolating windings are available with the result that interconnections between the regulators of various motions may be accomplished. This feature was provided on the two latest wheel excavators which have been placed in service by United Electric Coal Companies and Peabody Coal Co. Maximum overburden is removed when the ladder and stacker conveyor belts are kept full

of material. These conveyors are designed to be full when the wheel motor is loaded at peak power output. Therefore, to obtain maximum production peak loading of the wheel motor should be maintained. The loading of the constant speed wheel motor is determined by the digging force into the bank. This force is determined by the speed and torque of the swing motion. To relieve the operator from constantly adjusting the swing drive to suit the changing digging conditions, the swing and wheel Magamp circuits are tied together. The wheel load is measured by the IR drop in the commutating and compensating winding of the wheel motor and generator. This IR drop is fed into a bias circuit which is adjusted to correspond to the IR drop at peak power output of the wheel motor. When the wheel motor IR drop exceeds this bias voltage a current signal will feed into the swing Magamp to slow down the swing motion. With the slowing down of the swing motion the loading on the wheel biting into the bank will be reduced, causing a reduction in the wheel motor current until the IR drop will again correspond to peak power output. If the wheel is not loaded to peak power output the swing will adjust to swing faster to increase the loading of the wheel motor.

By tying these two circuits together the operator does not have to adjust the swing master switch continuously. It can be moved to maximum speed output and the feedback circuit used to cut down the speed and torque to maintain the wheel loading.

Controlling the 115-yd Shovel

On the large 115 cu yd super shovel being built for Peabody Coal Co., a computer study has determined the response required of each control component to coordinate with the motor and generator design parameters and to provide the performance calculated by the Bucyrus-Erie Co. The type of control on the hoist motion is to be a voltage regulator with current limit override. However, the computer results will be used to determine if any deviation from this general practice should be adopted.

Figure 3 is a one-line diagram of the typical control to be used for the hoist and crowd motions. The hoist drive will consist of eight motors and eight generators connected in four sandwich series loops. The control will consist of two duplicate systems to control the four motor-generator loops.

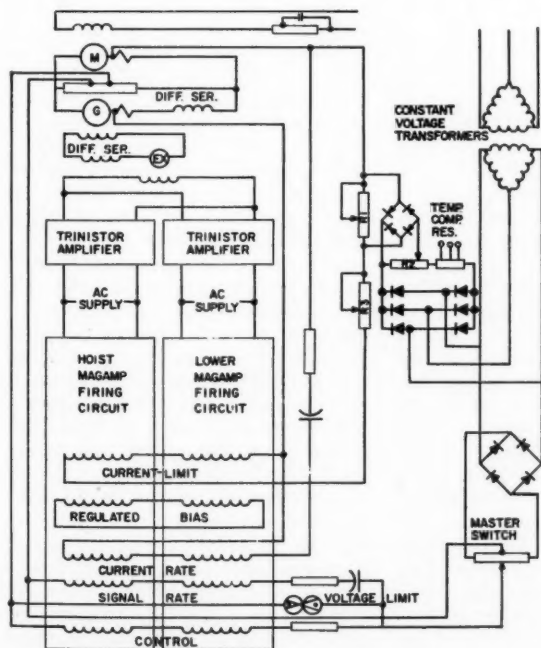


Fig. 3. Typical one line diagram of hoist Magamp-Trinistor-Exciter type control

One regulating system will control the fields of four generators in two loops and the other regulating system will control the other four generators in the parallel loops. The two regulating control systems will be interconnected by means of a load balancing circuit.

The crowd control system will also consist of the same size and type of regulator as that being supplied for each loop on the hoist motion. That is the same Magamp first stage regulator, Trinistor second stage amplifier, and amplifying exciter will be used on the crowd generators. For any master switch movement the Magamp firing circuit will trigger the Trinistor amplifier. The Trinistor amplifier in turn will energize the shunt field of the amplifying exciter. The amplifying exciter will force the generator shunt field to produce an output voltage and hence a motor speed proportional to the Magamp computed results. The rotating exciter is a natural, reversible, electrical amplifier and serves ideally between the primary regulator and the individual motion generators.

Here again, an automatic operating feature is to be provided in the control for this, the largest shovel in the world. To insure that maximum

production may be obtained from the shovel, the hoist motion must be operated at peak output power while loading the bucket. The crowd motion has a large influence upon the loading of the hoist motion. That is, if the crowd motion is forcing the bucket into the bank too fast and with too much torque the hoist motion will stall. Likewise, if the crowd motion does not have enough speed and torque to keep the bucket crowded into the bank when hoisting, the hoist could never operate at peak output. Therefore, the crowd motion operation should be tied to the hoist motion to automatically control the crowd motion speed and torque so that the hoist motion can be maintained at peak output power.

When cleaning up, and during spoiling operation, when the hoist motion is not operating up to a current value corresponding to peak power output, the hoist and crowd motions speeds and torques are determined by the master switch signal. If loading conditions should be such as to load the hoist motion above a current value corresponding to peak output power the control will automatically change the crowd motion to maintain the loading of the hoist motion at peak conditions.

This is accomplished by matching the hoist armature circuit IR drop against an adjustable bias supply. The bias voltage will be adjusted to be equal to the IR drop of the armature circuit when the current value corresponds to peak power output. When the IR drop is less than the bias voltage, the high gain regulator on the crowd will provide the crowd motion with the speed and torque necessary to increase the loading on the hoist motion. When this IR drop exceeds the bias voltage, a portion of the excess current will be fed back into the crowd Magamp regulator to slow down, stop, or even reverse the crowd motion to hold the loading of the hoist motion at peak conditions.

Conclusion

This is a far cry from complete automation in the excavating industry but it is a step toward progressive automation. It is a step in the direction to reduce the difference in production between operators—a means to improved production. Other improvements are on the drawing board and on test to exploit more fully the many advantages of this all static high gain regulating control system.

DISCUSSION:

By L. E. BLANCHETT

Chief Engineer
Bucyrus Erie Co.

IT has been recognized for some time that some degree of automation should be added to large excavator control equipment in an attempt to obtain better output. On very large shovels, where distances are great, it is extremely difficult for the operator to control the dipper so as to obtain the maximum load in the shortest time and with a minimum of abuse of machinery and electrical equipment. As pointed out by Mr. Vance, there may be a great difference between any two operators, one may have the ability to control the dipper in the bank to the extent that it is filled to overflowing with apparent ease, whereas another operator

will continually stall the dipper in the bank and will finally come up with only a partial load. In the latter case, the machine has been subjected to a great deal more punishment and with less actual results as far as output is concerned. In fact, one operator may take as much as 50 percent more time for a given cycle.

Unfortunately, there are a number of variables in connection with automated control of large shovels, namely; the path of the dipper in the bank, length of move-up, type of material being excavated, height of banks, etc. The degree of interlocking between the hoist and crowd would undoubtedly have to be different for heavy blocky material than would be the case for ordinary shale or clay material. The shape of the bank also presents a problem in that the digging conditions would be slightly different immediately after a move-up than would be the case after the move has

been practically dug out. Clean up work to maintain a fairly steep high-wall would also require special treatment. In a very high bank, a dipper may be loaded in the lower half of the bank, and therefore the second dipper load may be taken from the upper half of the bank.

An attempt was made several years ago to use interconnected hoist and crowd controls on a 40-cycle shovel, however, control elements used at that time had a relatively slow response characteristic, with the result that the dipper was either completely out of the bank or was completely stalled due to deep penetration in the bank. The fast responding static type controls available today should make this problem less critical to solve, at least to the point of partial automation, and therefore a definite aid to the operator. It is difficult to believe that the shovel cycle will ever become a predetermined type, since it prob-

ably will always be necessary to use an operator.

On the wheel excavator type machine, the limiting factor is usually the capacity of the belt conveyors. The present plan, as mentioned by Mr. Vance, is to automatically vary the swing speed in an attempt to keep the wheel at a constant output, by maintaining it at a constant power level and thereby obtain maximum belt loading. Again, there are many factors which stand in the way of complete automation, that is various types of material require different levels of power input to the wheel

drive. Sticky material tends to pack into the wheel buckets and will not unload properly. In this case, the power input to the wheel may be normal, but the wheel buckets may be bull-dozing the material in the bank instead of loading the belts, with the result that the belts are only partially loaded. Also, in heavy sticky material it is often times necessary to reduce the wheel speed, because this material will not flow properly on the slope sheet between the wheel and the belt conveyor. As in the case of the large shovel, automation can be an aid to the operator, however,

it does not appear that it can replace the operator. Even a small gain, however, in machine efficiency can mean a great deal in machine output, and the use of automatic controls should be carefully considered wherever a possible gain in efficiency is indicated.

In conclusion, it might be said that possibly the operator could have at his position a device which could be used to introduce different constants into the control system to take care of the digging variables and thereby effect the proper relation between the power units to obtain maximum operating efficiency.

DISCUSSION:

By R. W. BERGMAN

Electrical Engineer
Marion Power Shovel Co.
Marion, Ohio

MR. VANCE has discussed briefly a proposed automatic crowd control for use on a large shovel. To supplement his paper, we felt that a report on the field tests we have already conducted on such a system would be of interest.

A joint effort by the Marion Power Shovel Co. and the General Electric Co., the study was conducted on a Type 5761 shovel operating at Peabody Coal Company's Bee-Veer (Missouri) mine.

Discussion of the feasibility of a crowd-hoist regulator began several years ago. While such an interconnection seemed simple at first glance, it was soon apparent that many diverse problems had to be solved. For example, a means had to be provided for the operator to turn the automatic control on or off instantaneously, and the system had to be suitable for variable digging conditions and materials, the characteristics of which are largely unknown. Due to the many problems involved in this pioneering, and to reduce the time that the shovel would be shut down, it was felt advisable to make a study on an analog computer.

The computer made it possible to determine whether the regulated quantity should be position, hoist power, hoist torque, or hoist speed, to study the effects of the variable conditions such as cutting force required and height of bank, as well as the effect of such mechanical matters as front end geometry, etc.—all without affecting the production of the machine.

Using the results of the computer study, the circuitry was designed and the components were selected. The equipment was then installed on the machine along with test equipment to study the performance of the hoist and crowd motions as related to dipper position.

Preliminary tests were made to insure proper functioning of the operator's controls, protective circuits, and other auxiliary functions as well as the regulating system itself. Digging tests were then made under various conditions which included attempts to stall the hoist motion. The preliminary tests provided numerical data in place of some of the unknown quantities, narrowed the range of known variables and con-

firmed the existence of previously suspected, difficult-to-evaluate, system problems.

It has also been demonstrated that automatic crowd-hoist operation is feasible and that certain advantages can be expected, among which are the following:

- (1) More effective filling of the dipper.
- (2) Variations in operator dexterity are minimized.
- (3) Operator effort is reduced, thus reducing fatigue and keeping production high.
- (4) Reduced loading of the crowd motion, thus reducing maintenance.
- (5) Blasting techniques can be studied more accurately since the operator variable is considerably reduced.

Such tests are a continuation of the program of research and development aimed at improving the overall efficiency of these fine excavating tools. It is expected that the crowd-hoist regulator part of this program will be completed later this year at which time the techniques used may be disclosed without divulging proprietary information.



Careless handling of drill steel can result in damage and cause premature breakage. It is less subject to damage if stored in racks such as these

EFFICIENCY minded mine operators are constantly searching for methods of improving their drilling practices and cutting drilling costs. Every underground operation has its individual problems—a method used at one mine may not be workable at another. There are funda-

mentals that can be adapted to any type of drilling, however, and improvements that can be made. An exchange of ideas among operators through technical sessions at meetings, articles in technical publica-

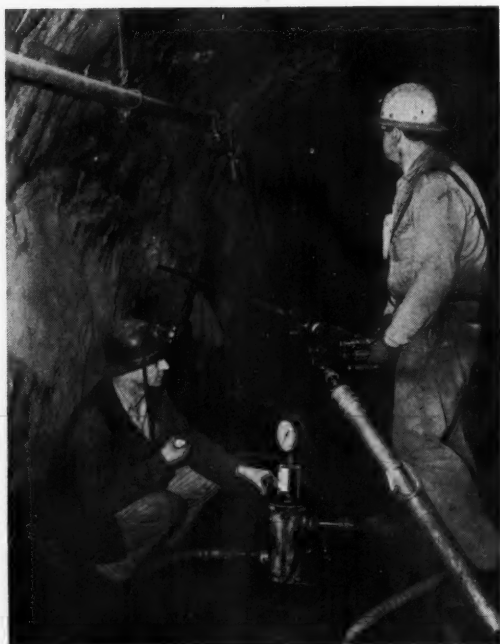
tions, and discussion wherever mining men get together are essential for the improvement of drilling practices.

Importance of Drill Performance Records

A good research program is invaluable in improving drilling efficiency. There is a wide variety of equipment available today, and tomorrow there will be something added. Research not only aids the operator in selecting the best equipment and maintaining it in the best workable condition, but aids the equipment manufacturer in producing better equipment.

It is important to keep an accurate record of the performance of all drilling equipment. The larger the operation, the more necessary these records become. One cannot rely on casual observation of the performance of equipment. At the Homestake mine, a number is stamped on every drill. The miners are required to record on their daily time reports the number of the drill used and the footage drilled. If a drill comes to the shop for repair and shows signs of mistreatment, it is possible to investigate the cause and prevent a recurrence of the damage. Repair costs are tabulated monthly for every drill.

A good research program is invaluable to the operator looking for ways to improve drilling efficiency. Here test engineers are ready to conduct a drilling speed test on an airleg using jointed rods



Improving Drilling Efficiency

Accurate records, a good testing program, preventive maintenance and adequate lubrication are major factors in improving drill performance and reducing drilling costs at the Homestake mine

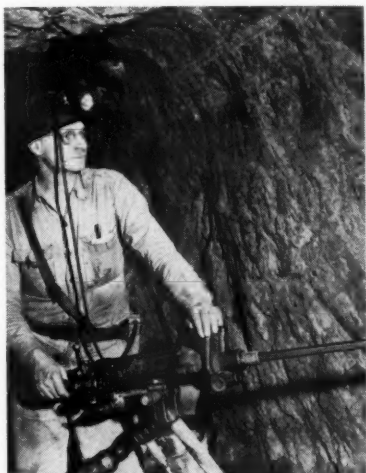
By WILLIAM C. CAMPBELL
Assistant Mine Superintendent
Homestake Mining Co.

Shop Inspects Equipment at Regular Intervals

Drills are sent to the shop at a specified regular interval for inspection and overhauling. The drill is completely dismantled and inspected. Worn parts are replaced, then the drill is assembled and tested before it is sent back to the miner. No repairs are permitted underground; a drill not working properly must be sent to the shop in exchange for another one in good working condition.

The drill repairman always checks the piston splines to see that the drill has been properly lubricated. Although the drill might be well oiled when sent to the shop, an inspection of the splines will show if it has been kept well lubricated. The use of airline oilers on all drills is required, and only the proper grade of oil is issued. The oilers are adjusted to supply the proper amount of oil by the drill repairman.

If the oiler is not working properly,



Rubber drill steel collars, which are used in place of forged collars, are being tested at Homestake. The collar is cemented to the steel with an epoxy resin

the miner is instructed to exchange it rather than to adjust it himself. If allowed to adjust the oiler, he is apt to keep the flow of oil at a minimum. The miner should observe the shank of his steel—if the drill is being properly lubricated there will be a film of oil on the shank. Automatic oilers, which shut off the air supply to the drill if it runs out of oil, are being used in some mines.

Chrome Plating Doubles Life of Airleg Cylinder

Lubrication of the air feed leg on stopers has always been a problem.

This can be overcome by drilling a small hole through the shaft and collar of the air feed piston. This introduces a fine spray of oil from the oiler into the feed leg.

Company records show that the average life of a cylinder in an airleg drill is about four years. In the past the walls of the worn cylinders were honed and oversize pistons inserted, adding about three years to the life of the cylinder. It was found that there was considerable leakage of air around the ports, however, and the practice has been discontinued. Now cylinders are reconditioned by chrome plating, which doubles the life at about one-third the cost of a new one. The added life adds some 85,000 to 100,000 ft of drilling footage to the cylinder.

The average life of valves in our drills is about three years; by refacing them in the machine shop their service life can be increased about 2½ years.

Excessive wear on chuck bushings has been reduced by making the rotating sleeve and chuck in one unit. When made separately, they get out of alignment when worn and cause excessive wear on the bushings. We find that the life of chrome-plated chucks is double that of non-chrome.

It is a good practice to have the water tube extend well into the drill steel to prevent backwashing the oil out of the fronthead of the drill. It also prevents breaking the tube when backing the steel out of the hole.

One source of trouble in some types of airlegs is the wearing out of the "O" ring on the control valve seat. When the "O" ring becomes worn, the valve cannot be completely closed, and when opened, the leg will jump forward. The miners are cautioned not to close the valve with a wrench as it will ruin the valve and the seat in the piston head. The "O" ring should be replaced when this happens.

Handling of Drill Steel

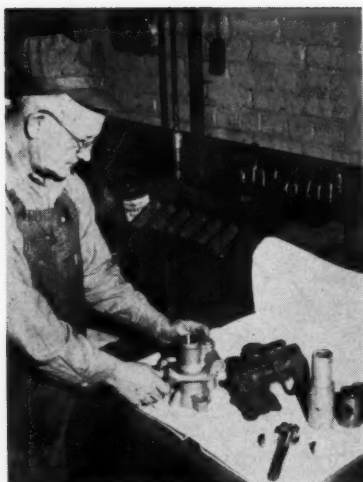
There is much to be said about the care of drill steel. It is not advisable to store an excessive amount of steel underground in humid conditions. Rust not only pits and weakens the steel, but when it scales off the threads or taper on the bit end, it leaves the steel undersize and can ruin the bit. Drill steel can be ruined by careless handling; a nick in a rod will cause it to break prematurely.

The life of drill steel can be shortened considerably by improper heat treatment when forging the collar or threading the bit end. Tests on rubber collars, cemented to the steel by an epoxy resin, in place of a forged collar are impressing. Knock-off bits in place of threaded, if proven satisfactory, will eliminate the need of heat treating the bit end for threads. Integral steel will do the same.

Although it is convenient to use standard length steel, it can be expensive to adhere to it strictly. If, for example, the shank breaks six in.

Drill steel life is greatly dependent upon proper heat treatment after forging. Here a drill steel foreman is checking the quenching time of a shank in an oil bath





Excessive wear on chuck bushings has been reduced by making the rotating sleeve and chuck in one unit. At right is a one-piece chuck and rotating sleeve beside a two-piece assembly

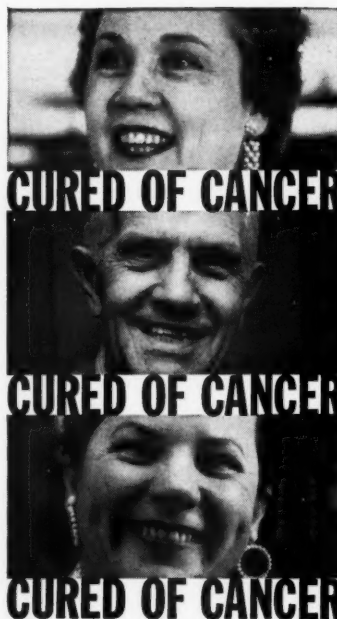
from the end of a nine-ft steel, and it is cut down to the next change—say six ft—a considerable amount of steel is wasted. In most cases, odd lengths of steel can be used.

Ways to Increase Bit Life

The loss of bits by careless usage, or pilfering, can be costly. An accurate record is kept of the number of bits issued to each crew, and the number returned each shift. The name or number of each crew is stamped on the bit rack. The bit sharpener records daily the number of bits in and out for each crew. The miners are instructed on the care of bits, emphasis being placed on not over-running; using the proper tool to tighten and loosen the bit; and not forcing a bit into a hole drilled previously with a smaller bit.

Quite often a bit becomes gauged before the inserts are worn out. A little grinding to increase the size of the waterway will add more footage. When the bit has become gauged to the skirt diameter, and has inserts left, the skirt can be ground down to a smaller diameter and used with a steel with a smaller diameter shoulder. A certain area can be set aside for using these bits so that the steel can be kept segregated. We have found that the cost of grinding amounts to approximately ten cents per bit, and an additional 50 to 60 ft of drilling is gained from the bit.

Bits which have damaged threads can be welded to short lengths of steel and used for blockholing. The handling cost is small and a lot of footage can be obtained from the damaged bits.



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Economics of Deep-Sea Mining

(continued from page 56)

cient job of mining, some means of controlling the location of the dredge heads must be provided. With television cameras and propulsion devices on the pipeline just above the junction of the suction arms, it might be possible to guide the dredge so closely-spaced, parallel cuts can be taken through a deposit. In such an operation some means of locating the dredge heads with respect to the control ship must be devised to keep the pipeline in a nearly vertical position so the suction heads are not lifted off the sea floor. Although it is doubtful whether such a method of operation would be used at the beginning of any deep-sea mining operation, a demand for increased efficiency would sooner or later require the design and use of some method for controlling the location of the dredge heads.

Cost of Processing Nodules

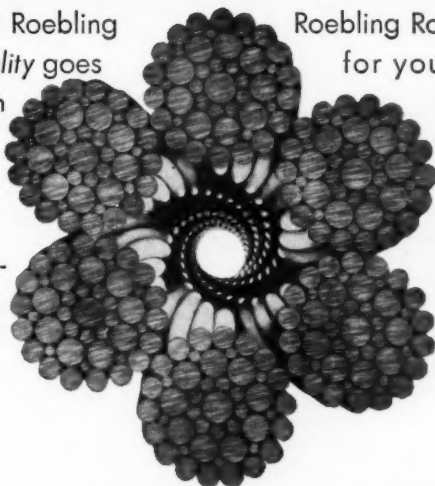
Studies of the physical and chemical character of the sea-floor manganese nodules indicate that standard hydrometallurgical techniques can be used to recover the metals in them. The ammonium-carbamate process⁴ could be used to recover the manganese from the nodules, and the Sherritt Gordon process⁵ could be used to recover the copper, nickel, and cobalt. Data from these processes indicates that the cost of processing a ton of the nodules into salable products would be about \$26.

The gross recoverable value of the metals found in manganese nodules ranges from \$40 to \$100 per ton of nodules at March 1961 prices; the value of the nodules found in the south Pacific Ocean averages about \$60 per ton. Thus, the mining costs listed in this article indicate that deep-sea mining could be a profitable enterprise.

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Supervisory Safety Training*

SUPERVISORY safety training is a worthwhile investment for any company and it should be a basic part of the safety activity of all mining companies. It may be likened to a seed which, properly planted and nourished in the supervisor, blossoms forth in the safe attitudes and work habits of the employees who are supervised.

Even though this training can pay great dividends in areas other than safety, many companies, especially the smaller ones, do little or no supervisory safety training because there is no course or program tailored for training mine supervisors. Most supervisory training courses and materials are general in nature and utilize factory type situations for examples or illustrations. Even if it were practical, it would be difficult to devise a training program that would be acceptable to many mining companies because of the diversity of mining methods, terminology and work practices.

Since supervisory safety training deals with universal principles which may be applied in any industry, it is to the advantage of every organization to utilize available training materials, adapting them to their specific needs.

It is the purpose of this article to suggest a range of activities that will enable practically any mining company to engage in some supervisory safety training, despite varying operating, financial and other restrictions.

What Comprises a Supervisory Safety Training Program?

Most mine managers, if asked whether their organization has a supervisory safety training program,

would unhesitatingly answer "Yes." If pressed for details, most of these would turn out to be composed of first aid training and mine rescue training courses in which the supervisors participate. Relatively few mining companies have developed safety training programs beyond this point.

First aid and mine rescue training are definitely safety training and should be classed as supervisory safety training because the supervisory force participates in the program, often furnishing the instructors. But does this really comprise a supervisory safety training program?

This can be answered best by defining "supervisory safety training program." It may be defined as a "plan to train supervisors in the art of accident prevention." A good program will have the following characteristics:

1. It will be a planned program.
2. It will consist of a comprehensive study of safety problems, rather than just one or two areas of safety.
3. Course material will be designed primarily for supervisors.
4. The primary objective of the course will be to motivate and to enable the supervisor to transmit the idea of safety to others rather than just to instill the idea in the individual supervisor.

From the foregoing, it should be readily apparent that first aid and

mine rescue training, while essential components of a program, do not of themselves compose a supervisory safety training program.

A program that meets the conditions listed above has all the elements of an effective supervisory safety training program. If training activities do not meet these tests, a tool that will reduce accidents, improve production, and reduce costs is being neglected.

Arranging for Training Periods

Perhaps the most frequent reasons given for not initiating a supervisory safety training program are the lack of time to devote to training and the difficulty in assembling a sufficient number of supervisors for group meetings over a period of time in order to conduct training.

Managers are human, of course, and like most people, they often cannot find time for things in which they have no real interest. In many cases, therefore, what is required is an abiding belief in the value and benefits of supervisory safety training; once management has attained a sincere desire to train supervisors in the promotion of safety, it is surprising how easily obstacles can be overcome. Therefore, the first way to arrange time for training is for management to harbor a conviction that it is a valuable tool that will pay dividends in accident prevention, production, and cost reduction. If management has this attitude, training time will acquire a priority on the activity schedule.

There are, however, organizations where management has a sincere interest in supervisory safety training but, because of shift schedules, finds it difficult to arrange suitable time for training. There are several suggestions which may be considered to alleviate this situation. For instance, training sessions could be scheduled

The primary objectives of a supervisory training program are to motivate and enable the supervisor to transmit the idea of safety to others



* Prepared by the Safety Training Committee, Mining Section, National Safety Council, Harold L. Bare, Chairman.

on off-shift periods, such as evenings or weekends, when a majority of the supervisors would be available. If these meetings were to be scheduled on a monthly basis, it would not be too great an imposition on the free time of supervision, although some companies might find it advisable to pay their supervisors for such meetings. If it is desirable to hold training sessions during working hours, regular supervisors might be replaced for a few hours each month by substitute supervisors such as those normally used during vacation periods. Depending on circumstances, it might be practical to hold evening meetings when most supervisors are not scheduled and replace those who are on shift with substitutes.

If it is not feasible to hold separate meetings for training purposes, thought should be given to the utilization of a portion of other regularly scheduled meetings. This type of training is suitable for inclusion in any safety meeting, but it should also be considered as a valid portion of a production or operations meeting, since safety definitely affects both of these areas.

Many organizations who hold regular foremen's meetings often show films as a part of or as a feature of the meetings. This offers a way to introduce supervisory safety training without scheduling additional meetings.

Use Periods of Reduced Operations for Training

An opportunity for safety training which is sometimes overlooked is the use of periods of reduced operations for training sessions. Many companies periodically find it necessary to schedule mine operations for a three or four day week, but as a matter of company policy, salaried supervisors are scheduled for a five day week. The non-operating day of each short-time work week provides an excellent opportunity for training sessions, especially since the usual excuses, such as interfering with production, lack of time, and the difficulty of getting supervisors together, have no validity. Since these opportunities are not prearranged, it is important that a program be planned in advance so that it can immediately be put into effect when the opportunity presents itself. If no preplanning is done these opportunities slip past because, when a period of reduced operations does occur, the schedule is often back to normal by the time a program is planned and training material obtained. However, if plans are set, and

FIG. 1. SUPERVISORY SAFETY TRAINING PROGRAMS FOR MINING COMPANIES

1. Mines which have no opportunity for group training (small plants or mines which do not hold meetings or those which have one or two supervisors in a number of isolated locations)
 - a. Foreman's home study course
 - b. Monthly mailing or distribution of the following pamphlets:
 1. "Psychology of Safety in Supervision"—Set of six booklets by Dr. J. L. Rosenstein
 2. "Personal Development Series"—Set of six pamphlets containing talks given at six National Safety Congresses.
 3. "Men and Motives in Safety Supervision"—Set of six booklets by Glenn F. Griffin
 - c. Subscription to the "Industrial Supervisor" for each supervisor.
2. Mines which have limited opportunity for group training (plants or mines which have foremen's meetings on a weekly, biweekly or monthly basis). Many medium-sized plants assemble most of their force at more or less regular intervals for operations, safety, or combined safety-operations meetings. If no other training opportunity exists, portions of these can profitably be allotted to supervisory safety training.
 - a. "Supervisors Safety Manual." Requires approximately 30 minutes of each meeting. Assign a chapter for reading prior to the meeting, having each supervisor complete the quiz for the assigned chapter as given in the instructors guide. Have the quizzes corrected during the meeting and discuss the questions to make sure that everyone knows the correct answers. The Manual can be covered in twelve meetings using this method.
 - b. "Foreman's Home Study Course." Supervisors can be enrolled as a group and assigned lessons on a group basis. Examinations, which are more comprehensive than in "a," can be completed by the individuals and sent into the NSC for correction. Completed examinations will be corrected and returned in time for discussion at the next monthly meeting.
 - c. "Men and Motives in Safety Supervision." Set of six booklets by Glenn F. Griffin. Use same procedure as outlined in "a" above to cover one booklet per meeting.
 - d. Supervisory safety training motion pictures
 - No One Else Can Do It
 - Fact Finding, Not Fault Finding
 - Foresight—Not Hindsight
 - What They Don't Know Can Hurt
 - Call 'Em on the Carpet
 - It's an Order
 - Fragile—Handle Feelings with Care
 - Let's Talk About Safety
 - Take a Talkie Break
 - Setting 'Em Straight
 - Let Everybody Help
3. Mines which can schedule group training sessions for supervisors on a regular basis
 - a. Supervisory safety course based on "Supervisors Safety Manual"—18 class hours based on 12 or more weekly classes. Instructors guide available.
 - b. "Metal Mines Accident Prevention Course"—Can be arranged through regional U. S. Bureau of Mines Offices.
 - c. "Men and Motives in Safety Supervision"—Set of six booklets by Glenn F. Griffin. Use as course of six class hours. Leader's training guide available.
 - d. Review of state or provincial mining act.
 - e. Review of company safety rules.
 - f. First aid training courses.
 - g. Mine rescue training course.
 - h. Specific training programs developed by the company safety department.

training material is obtained in advance, a supervisory training program can be instituted during the first week of a period of reduced operations.

We have considered several suggestions to aid companies in the scheduling of supervisory safety training sessions. Any company that is not now engaged in such a program, should be able to use or adapt one of these methods to initiate one of its own. It all boils down to—"Where there's a will, there's a way."

Selecting a Safety Training Program

Every mining company, whatever its size, should have a safety training program for its supervisors. It is easy to find excuses for not undertaking such training—lack of time,

too many meetings already, can't take the supervisor away from his job, no one to do the training, etc.

No matter what the objection, operating problem or schedule difficulty, some sort of program can be devised to fit in with the limitations imposed by size, schedules, operating problems, etc. It goes without saying that every mine cannot, for various reasons, set up a full fledged training program, but every mine can set up one in which its supervisors will get some safety training.

Shown in figure 1 are three suggested programs that should fit practically any situation and permit every company to initiate a meaningful supervisory safety training program. Unless otherwise noted, all materials listed are available from the National Safety Council.

wheels of government



As Viewed by **HENRY I. DWORSHAK** of the American Mining Congress

Major unfinished business forced Congress to abandon plans to adjourn by Labor Day, and its leaders are now shooting for a wind-up no later than October 1. In view of the Soviet Union's decision to resume testing of nuclear bombs, and the resultant heightening of international tension, it is conceivable that Congress may remain in session even longer.

Among unfinished business are appropriations for foreign aid and domestic public works. Legislation to expand Federal financial aid to education has been dropped, but may again be considered next year.

WILDERNESS BILL PASSED BY SENATE

After two days of debate, the Senate passed, with amendments, 78 to 8, the controversial legislation which would establish a National Wilderness Preservation System. The bill was approved late in July by the Senate Interior Committee.

As passed by the Senate, the System would be composed initially of about 15 million acres of national forest lands classified by the Forest Service as wilderness, wild or primitive areas. These lands are now subject to the general mining laws, but the Wilderness Bill would limit prospecting and mining on these lands to specific areas selected by and under regulations prescribed by the President.

As passed the measure would permit activity for the purpose of gathering information about mineral resources, provided that such activity "is not incompatible with the preservation of the wilderness environment." The mining industry believes that this amendment is virtually meaningless, because it is extremely questionable that anyone would incur the expense of even limited surface prospecting where he does not have the right to locate a claim and develop any deposit he might discover.

During the first day of the debate,

★ ★ ★ ★ ★ **WASHINGTON HIGHLIGHTS**

CONGRESS: Adjournment date pushed back

WILDERNESS BILL: Passed by the Senate

TAXES: House Committee defers action

HANFORD PROJECT: Senate approves compromise

MINE INSPECTION: Study bill passed by House

FUELS: Resolution calls for Committee study

TARIFFS: Committee okes lead-zinc bill

LEAD-ZINC: House passes subsidy measure

★ ★ ★ ★ ★

The measure will now go to the House Interior Committee, which has indicated that it plans to consider no further legislation this session.

COMMITTEE DEFERS ACTION ON PRESIDENT'S TAX PROGRAM

The House Committee on Ways and Means, which is the Congressional "clearing house" for Federal tax legislation, has announced that it will not approve a bill this year on the President's recommendations for tax revision, but will take the subject up early in 1962 and may report a bill to the House in February. The Committee made public a "discussion draft" of a bill containing revisions which were tentatively agreed upon earlier in the year, with the hope that public study and comment would assist it in work on the program during the next session of Congress.

The "discussion draft" deals with an 8 percent investment incentive credit, disallowance of various entertainment expenses, recapture of depreciation when tangible personal property is sold, withholding of income tax at the source on interest and dividends, limited changes in the treatment of income earned outside the United States, and the taxation of mutual insurance companies and co-operatives.

SENATE APPROVES COMPROMISE HANFORD ELECTRIC PROJECT

The Senate has adopted and sent to the House a compromise version of the Atomic Energy Commission authorization bill containing funds for construction of an electric power plant at the Hanford, Wash., nuclear reactor. The House was expected to consider the conference report later this month.

As introduced, the AEC bill had contained \$95 million for this Hanford project. The House deleted the project on the basis that it would put the AEC into the business of selling electric power in competition with private enterprise, but it was restored

the Senate rejected, 41 to 32, a motion by Senator Ellender (Dem., La.) to refer the bill to the Senate Agriculture and Forestry Committee with instructions to report it back not later than February 5, 1962.

On the second and final day of the debate, the Senate rejected, 53 to 32, an amendment by Senator Allott (Rep., Colo.) to require affirmative Congressional approval of any Presidential recommendation regarding a wilderness area; also rejected, 51 to 35, an Allott amendment to give to the Secretary of Agriculture or the Secretary of the Interior, rather than the President, the determination as to authorization of certain activities within the Wilderness System.

Amendments which were adopted and passed with the wilderness measure were minor in nature. Included were amendments by Senator Miller (Rep., Iowa) providing for hearings within 30 days on any resolution of opposition to any Presidential recommendation pursuant to the bill, and by Senator Bennett (Rep., Utah) respecting access to State-owned land surrounded by any area in the Wilderness System.

by the Senate. The conference report would provide \$58 million for one generator to produce about 400,000 kilowatts of power—approximately half the power initially proposed. The compromise also provides that the electric energy generated by the new Hanford facility shall be used exclusively by the Commission in connection with the operation of the Hanford reactor.

The report said that the compromise authorization "does not contemplate commercial sales of electric power by the Commission. * * * The disposition of energy produced by these facilities will be similar to the practice followed at other AEC sites where electricity is generated incident to the operation of government-owned reactors."

The compromise measure also includes \$5 million for "study, development and design for nuclear processes which have application for improving and utilizing coal and coal products." The report added that this authorization "will be used to explore the areas in which nuclear energy may be used to aid the coal industry. Among the projects for which this authorization might be used are research and development work in the use of radioisotopes in the coal industry, gasification of coal by high temperature nuclear heat, and related laboratory investigations into the nature of radiation-induced chemical reactions. Provision is made for participation by the Department of the Interior through its Bureau of Mines and, in connection with research work, the Office of Coal Research, by means of interagency agreements and transfers of funds."

HOUSE PASSES BILL FOR METAL MINE SAFETY STUDY

A bill to authorize the Secretary of the Interior to conduct a two-year study of safety and health conditions in the Nation's metal and nonmetallic mines was passed recently by the House. The measure, which is now in the Senate Labor Committee, would require the Secretary to report his findings to Congress together with any recommendations as to the need for Federal inspection of these mines.

The study called for would cover such matters as causes of injuries and health hazards, the relative contribution to safety of inspection programs embodying (1) right-of-entry only and (2) right-of-entry plus enforcement authority, the effectiveness of health and safety education training, and the scope and adequacy of State safety and health laws relating to

metal and nonmetallic mines and the extent of their enforcement.

NATIONAL FUELS STUDY PLANNED BY COMMITTEE

The Senate Rules Committee is now considering a resolution which would authorize the Senate Interior Committee to make a thorough study of (1) current and prospect fuel and energy resources of the United States and the present and probable future rates of consumption thereof, and (2) existing and prospective governmental policies and laws affecting the fuels and energy industries to determine what, if any, changes and implementation of these policies and laws may be advisable in order to coordinate and provide an effective national fuels policy.

In addition, the resolution would authorize the President of the Senate, at the request of the Chairman of the Interior Committee, to appoint three Senators who are not members of that Committee to participate in the study. Results of the study would be reported to the Senate "at the earliest practicable date," together with any recommendations deemed advisable.

The coal industry has long urged Congress to make a study of this type. Joseph E. Moody, president of the National Coal Policy Conference, said he was confident that "the resolution as reported out can fully accomplish the very critical objectives which its supporters have sought."

ANDERSON LEAD-ZINC BILL GETS COMMITTEE APPROVAL

The Senate Interior Committee has approved, with amendments, the Anderson bill to establish subsidies on domestically produced lead and zinc and to place import taxes on imports of the two metals and their ores and concentrates. The Senate leadership has not indicated whether the measure will be considered this year.

As amended, it contains lead-zinc subsidy provisions identical to those in the Edmondson bill passed last month by the House (see below). The subsidies would be paid from receipts from import taxes.

The measure would also import taxes of 2 cents per pound on lead and zinc metal plus an additional 2 cents per pound which would apply, on a quarterly basis, whenever prices are below 13½ cents per pound in the case of either metal. Import taxes on ores and concentrates would be 1.4 cents per pound (metal content) on a permanent basis, plus another 1.4 cents during any period when the additional 2 cents is being levied on

lead or zinc. Present tariff duties would be revoked. The Anderson bill would also place compensatory import taxes on manufactured articles of lead and zinc; these would be in addition to present tariff duties.

HOUSE PASSES EDMONDSON LEAD-ZINC SUBSIDY BILL

Last month the House passed, 196 to 172, an amended bill by Rep. Edmondson (Dem., Okla.) to provide a limited program of Federal subsidies for small producers of lead and zinc. In the Senate, the bill was made part of the Anderson lead-zinc bill (see above), so it is unlikely that the Senate will get to vote on it.

This bill would provide for payments by the Secretary of the Interior to small domestic producers of 75 percent of the difference between the market price and 14½ cents per pound for lead and 55 percent of the difference between the market price and 14½ cents per pound for zinc. Subsidies would be paid to each eligible producer on up to 1,500 tons of each metal in the calendar year 1962, 1,200 tons in 1963, 900 tons in 1964 and 600 tons in 1965, final year of the program.

To be eligible, a producer could not have mined more than 3,000 tons of lead and zinc combined during any one of the past five years, and no producer could be paid for tonnage produced in any year in excess of his maximum production during any of the calendar years 1950-1960. Payments could be made only on ores and concentrates produced from an operating unit that has been in actual production sometime during the past five years.



"Well you asked for a light . . ."

personals

Robert W. Bruce, former senior vice president of Pittsburgh National Bank, has been named president of Jewell Ridge Coal Corp., and Jewell Ridge Coal Sales Co. He succeeds **Huston St. Clair**, who has been elected chairman and chief executive officer of the two companies.

K. C. Li, Jr., chairman and chief executive officer of Wah Chang Corp., has been named a director of Howe Sound Co. He succeeds his father, the late **K. C. Li, Sr.**, in this post.

John Edgar was recently elected vice president of Sunshine Mining Co. Formerly general manager of the Mining Division, Edgar has been with Sunshine for 26 years. He joined the company in its Engineering Department and has been successively chief engineer, superintendent, general manager of Kellogg Operations and, for the past four years, general manager of the Mining Division. Edgar is active in the affairs of the Idaho Mining Association, Northwest Mining Association, and American Mining Congress, and is a member of the Natural Resources Committee, U. S. Chamber of Commerce, and of AIME.

W. J. Shields has been elected vice president—operations of Rochester & Pittsburgh Coal Co. Shields has been with Rochester & Pittsburgh since his graduation from Pennsylvania State University in 1935. He has been division engineer, assistant mine foreman, mine superintendent, chief mining engineer and assistant general manager, the position he held at the

time of his promotion to vice president.

A. C. Sedlachek, an authority on the use of coal in coke-producing, has been appointed assistant to the vice president in the Coal Division of Eastern Gas & Fuel Associates. Sedlachek, working from the division's Pittsburgh headquarters, will advise on special problems involving the application of Eastern's metallurgical coal to coking processes. Sedlachek for the past seven years has been manager of the company's Everett coke plant and blast furnace.

William J. Orlandi was appointed director of the Illinois Department of Mines and Minerals, effective September 1. He was previously assistant vice president of Peabody Coal Co. in the St. Louis

Division. In this new post, Orlandi replaces **Ben H. Schull**, who has been director of Mines and Minerals for the past eight years.

Cleon R. Fowler, general manager of the Pocahontas Fuel Co. Division of Consolidation Coal Co., has assumed additional duties as vice president. Fowler has been with the Consol organization since 1940 when he joined Christopher Coal Co. as production engineer. He served in various operating posts until being named general manager of Pocahontas last year.

Other promotions include the naming of **Alfred E. Copeland** as assistant to the president of Pocahontas and **Charles W. Porterfield** as assistant chief engineer. They had been, respectively, assistant chief engineer and mechanical engineer.

Charles W. Berry, mine taxation engineer with the Minnesota Tax Commission, has joined the Department of Mining, Pennsylvania State University, as research assistant. He will be in charge of developing the program of operations research for the mining industry now being undertaken at Penn State.

1962 AMC Coal Convention



L. H. Chalfant, manager, Bethlehem Mines Corp., has accepted the chairmanship of the Program Committee for the 1962 Coal Convention of the American Mining Congress to be held in Pittsburgh, May 6-9.

Chalfant will head a nation-wide committee of mine operators and equipment manufacturers in developing the program for the convention, at which the industry will deal with various important problems confronting it and will spell out the latest advances in methods and equipment for mining and processing coal. Goal of the committee is an intensive three-day program presenting new ideas and fresh approaches to spur technological advances and to help all mining

men—from top management to the miner at the face—do a better, more economical and safer job of extracting and preparing coal.

Coal companies are continuously developing significant improvements which could help the entire industry in its highly competitive battle for the Nation's energy markets. Everyone familiar with worthwhile developments is invited to suggest topics and speakers for the 1962 Convention. Send them to the American Mining Congress, Ring Building, Washington 6, D. C. The Program Committee will meet in the near future to review the entire field of mining, preparation, safety and management problems with a view to drawing up a well balanced program.



John L. Ryon, Jr., has been appointed director of production, International Salt Co. Ryon was formerly assistant director of production under **Floyd G. Parrish** who retired in August after 38 years with the company.

Ryon has been with International Salt since 1949. As director of production, he will coordinate all production activities of the company's four rock salt mines and three evaporated salt refineries located throughout the country.

William P. Hewitt, former senior geologist of the Western Mining Department, American Smelting & Refining Co., has been appointed director of the Utah Geological & Mineralogical Survey. He succeeds **Arthur Crawford** and comes to his new post after 28 years with Asarco in Mexico and the Western United States.

Stanley H. Cohlmeier is now general superintendent of the Atlantic City, Wyo., mine of Columbia-Geneva Steel Division, U. S. Steel Corp. Cohlmeier has been on the Atlantic City project since 1956. Before that he was chief estimator with Western-Knapp Engineering Co. for one year. Earlier he was with White Pine Copper Co. as assistant project manager at White Pine, Mich., and until he joined White Pine, was superintendent of Chestnut Hill Zinc Co., Galena, Ill.

R. L. Aston, consulting mining engineer and geologist of Aston Mineral Engineering Service, Elberton, Ga., has been appointed to supervise exploration and development of new quarries by Coggins Granite Industries of Elberton.

George Deneris, industrial engineer at the electrolytic refinery of Utah Copper Division, Kennecott Copper Corp., has been named plant maintenance superintendent at the company's Garfield smelter. Deneris joined Kennecott in 1948.

Cyril H. Mealing, operating superintendent at The Bunker Hill Co. silver refinery and cadmium plant, Kellogg, Idaho, has retired. Mealing was with the company for 33 years, prior to which he was on the engineering staff of Silversmith Mines Ltd. in British Columbia for two years.

Beatrice Pocahontas Co., which is owned by Republic Steel Co. and Island Creek Coal Co., has elected eight directors, four of whom are officers of Republic including **T. F. Patton**, president and chief executive officer; **E. R. Johnson**, assistant president and first vice president; **J. R. McVicker**, general manager of coal mines; and **W. T. Adams**, vice president-manager, purchases and raw materials. The other four directors are from Island Creek and include **R. E. Salvati**, chairman and chief executive officer; **J. L. Hamilton**, president; **C. R. Mabley, Jr.**, vice president-sales; and **N. T. Camicia**, vice president operations.

Salvati and Hamilton have been named chairman and chief executive officer, and president, respectively, of Beatrice, while **W. J. DeLancey**, **W. B. Boyer**, and Camicia have become vice presidents. DeLancey and Boyer are respectively vice president-general counsel and vice president-treasurer of Republic. **B. H. Early**, Republic assistant general counsel and **F. C. Honchell**, Island Creek vice president-finance, were named Beatrice's secretary and treasurer, respectively.

Fred B. Bullard has been elected president of the Kentucky Coal Operators Association. He had been executive secretary until the group recently changed its organizational setup at which time former president **B. F. Reed** was elected chairman of the board. The association is moving its headquarters from Hazard, Ky., to Lexington. Bullard is also executive secretary of the Hazard Coal Operators Association and administrative secretary of the Big Sandy-Elkhorn Operators' Association.



in a consulting capacity and lately with the company's asbestos interests in northern California.

Merritt has been in the mining industry since 1928 and early in his career served as a geologist with Selection Trust Limited in Africa and for the Department of Mines in Colombia, South America. For six years

he was with American Cyanamid Co. From 1946 to 1954 he was with the Atomic Energy Commission, first as geologist in charge of raw material procurement for the Manhattan Project and then as assistant director of exploration in the Raw Materials Division. He was senior geologist for E. J. Longyear Co. for five years, and became a consultant in 1960.

OBITUARIES



L. C. (Mose) Mosley, widely known and respected manager of the mining division of Marion Power Shovel Co., died August 28 in Cleveland following heart surgery.

He had been associated with Marion for 36 years and was manager of the company's mining division since 1946.

Mr. Mosley joined Marion as an application engineer in 1925 following employment with General Electric Co. and Hudson Coal Co. Specializing in the application of shovels and draglines for open pit coal mining, he studied mines all over the U. S. and Canada and developed mining plans for many foreign countries. He was active for many years in the American Mining Congress, the National Crushed Stone Association, the National Sand and Gravel Association and the American Institute of Mining Engineers.

J. E. Berg, 71, retired general manager of the Northwestern Mining Department, American Smelting & Refining Co., died in Olympia, Wash., on August 9.

Mr. Berg spent 37 years of his mining career in the Coeur d'Alene District of Idaho, retiring in 1955. From 1918 to 1923, he was an engineer and geologist with Day Mines. For the next 12 years he was associated with Federal Mining & Smelting Co., serving at the Morning mine and becoming superintendent at the Page mine. In 1935 he was named general superintendent for Asarco in the district and became general manager of the Northwestern Mining Department in 1947.

Harry J. Sherman, 61, general superintendent of Evans Elkhorn Coal Co. operations at Wayland, Ky., died in Huntington, W. Va., on August 16.

NEWS and views



First Office of Coal Research Contract Awarded

Award of a \$139,000 contract, the first to be issued by the newly created Office of Coal Research has been announced by the Department of the Interior. More than 100 contract proposals are now being evaluated by the Office of Coal Research, and additional contracts will be issued in the near future.

The original contract, issued to Booz-Allen & Hamilton of Chicago, calls for a study designed to identify new products which would enable present coal markets to be expanded and new markets to be generated. It is directed primarily to stimulating coal output by raising demand through the development of new products which are economically and technically marketable.

Director of Coal Research George A. Lamb predicted that practical proposals for improving industry practices concerning research, development and new product management will be developed. Explicit areas for further useful research to be sponsored, co-sponsored, promoted, or contracted for by the Office of Coal Research are expected to be found, he said. Results of the study are expected to be available not later than March 31, 1962.

U. S. Steel Purchases Florida Cement Facilities

The Universal Atlas Cement Division of U. S. Steel Corp. has announced it plans to service the south Florida cement market. Universal Atlas has reached agreement to purchase from Ponce Products, Inc. the latter's cement storage and handling facilities located at Port Everglades, Fla. In addition, arrangements have

been made for the use of the self-unloading bulk-cement carrier, S. S. Florida State, now owned and operated by Ponce Products for the transportation of cement from Ponce, Puerto Rico, to Port Everglades.

Ohio Strip Mining Industry Receives Award For Conservation Work

The Ohio Conservation Congress, a federation of conservation clubs, has chosen the Ohio Reclamation Association for its 1961 Industry Award. The Reclamation Association represents about 100 companies engaged in coal strip mining activities in Ohio.

Over 50,000 acres of strip-mined lands have been reclaimed by the Ohio Reclamation Association, the Association's principal function being the reclamation of lands affected by its member industries. The Association is the biggest tree planter in the State of Ohio planting an average of 2,500,000 each year. In addition, the Association seeds grasses and legumes on from 3000 to 5000 acres, plants trees on adjacent lands not directly affected by mining operations, and plants around 30,000 shrubby species specifically for wildlife food and cover. Much of the reclaimed land is already productive and a great deal of it is open to public recreational activities.

National Gypsum Announces 14-Year Expansion Plan

National Gypsum Co. has announced that it will invest \$72,000,000 in the next 14 years in doubling the 12,000,000-bbl capacity of its Huron Portland Cement Co. division plant at Alpena, Mich. The company also announced plans to build at Waukegan the division's 13th cement dis-

tributing plant with a storage capacity of 150,000 bbl.

The Waukegan plant is expected to be completed by winter. It will be built on water-front property adjoining the company's gypsum products plant, erected in 1959. The site will be leased from the Waukegan Park district.

A new rotary kiln will boost the capacity of the Alpena mill to 14,000,000 bbl. A new crushing and drying system also will be built. The former ocean-going oil tanker, the Huron, will be converted into a dual-purpose cement and coal carrier for service by 1963. The ship's 55,000 bbl cement capacity will make it the largest cement carrier on the Great Lakes.

Coal Produces 74 Percent of TVA Power

Tennessee Valley Authority has announced that power production was at an all time high during the 1961 fiscal year, which ended on June 30. Of the total net generation of 64,517,177,449 kwh, 16,890,222,729 kwh, or 26 percent, was generated by hydro plants, and 47,626,954,720 kwh, or 74 percent, was produced in steam plants.

The system heat rate averaged 9500 Btu's for each net kilowatt-hour generated. Previous low was 9590 Btu's. The steam plants burned 19,150,472 tons of coal in fiscal 1961, an average of 0.804 lb per kwh. The fuel burned cost \$74,121,830, or 1.766 mills per kwh.

Phosphate Rock Producer Enlarges Plant

Virginia-Carolina Chemical Corp. has increased its annual capacity by 400,000 tons and incorporated several

novel features, including closed-circuit television, in its operation.

V-C has installed a new 10 by 160 ft rotary kiln at its processing center in Nichols, Fla. A variable-speed feeder, controlled by a continuous weighing device governs the flow of feed from a 1100 ton capacity surge tank.

From a compact, air-conditioned control room, the operator can make feed and firing rate changes as well as control oil flow, air flow, and the temperature of the finished product as it emerges from the cooler. A special closed-circuit TV set-up allows him to see inside the kiln without leaving the control room. A conveyor belt takes the finished product from the cooler to a 100 ft high elevator, from which it is discharged onto a shuttle conveyor on top of product storage bins. About 15,000 tons of calcined rock can be stored in five bins. There are automatic protective devices on raw feed level, product temperature, and exhaust gas temperature.

Alabama Iron Industry May Expand

Veins of brown iron ore, identified as limonite, may extend across Alabama from the Chattahoochee River into Mississippi and across the river into Georgia. This prediction was made by Philip L. Lemoureaux, Alabama State geologist, who is making extensive core tests in several southeastern Alabama counties. Several hundred cores in Barbour, Crenshaw and Pike Counties are completed and tests are continuing. The tests are being made because of interest in establishing a steel mill in the vicinity of Eufaula, Ala. The State of Georgia is also making a bid for the plant and coring tests are being made on the Georgia side of the river, which divides the two states. Cores taken so far show thickness from two to six ft, but in the vicinity of Luverne the veins are more than 10 ft thick.

ALSO . . .

The Anaconda Co. announced recently that the Andes Copper Mining Co., a subsidiary, will build an electrolytic copper refinery at Chanaral, Chile. This unit will be constructed in three steps, and when completed will have capacity sufficient to refine the present copper output of the El Salvador mine. Anaconda said it will also have the capacity to refine 40,000,000 lb a year of the product of small and medium Chilean mines which is smelted at nearby Paipote.

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#2: hardening and cracking of cable jackets

Dear Steve,

We have been losing some cable because the jacket becomes hard and brittle. Then cracks develop and we have to replace the cable. Any idea of what may be causing these cracks? And is there anything we can do to prevent this kind of failure?

L.F.P., Pennsylvania

Dear L.F.P.,

Brittle, cracked or crazed jackets indicates a heat problem. When cable insulation and jackets are overheated for long periods of time they tend to grow hard and brittle, and crack when they ought to bend. There are several causes for cable overheating:

1. The conductor is too small, or;
2. Operating voltage is too low, or;
3. Cable length is excessive, or;
4. Overload protection is inadequate or non-operating, or;
5. Cable rating has not been decreased even though there are several layers on the cable reel.

Current rating for cable is based on one cable in air, with nothing near it to prevent removal of heat by the air. When cable is wound on a reel, natural ventilation is no longer sufficient, and the current rating goes down, like this:

One layer	.85 of specified value
Two layers	.65 of specified value
Three layers	.45 of specified value
Four layers	.35 of specified value

You can help lick the heat problem and increase cable life by following these two practices:

1. When you're working near the power source, remove excess cable from the reel to make sure it gets plenty of ventilation;
2. Reverse the ends of the cable periodically, so that the same section is not always exposed to the high temperature normally found near the reel. A good time to do this is when you remove the cable for permanent repairs. Mark the cable ends, and you'll always know which was which.

Steve Bunish will be glad to answer your minepower problem. Simply write it up and send it to "Minepower," c/o Steve Bunish, Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

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A joint meeting of the Industrial Minerals Divisions of the Canadian Institute of Mining & Metallurgy and the Society of Mining Engineers, AIME, will be held at the Chateau Laurier Hotel in Ottawa, Ontario, October 1 to 3, 1961.

Marquette Cement Mfg. Co. has begun construction on a major distributing plant in the harbor at Waukegan, Ill., which the company expects to have in operation by November 1.

Initially, the plant will consist of a bank of three 143-ft silos having a total cement storage capacity of 62,000 bbls, plus an adjoining packing plant and the latest facilities for loading both packaged and bulk cement onto trucks for delivery to customers in northeastern Illinois.

Cement of all types will be supplied to this plant by river-lake barge from the Marquette plant at Oglesby, Ill.

Peabody Coal Co. has announced that its strip mine in western Kentucky which will serve the company's new 4,000,000 ton-per-year long-term contract has been officially named the Sinclair mine. Peabody has also begun construction of a new strip mine eight miles northeast of Columbia, Mo. To be called the Mark Twain mine, it will produce between 400,000 and 500,000 ton per year. The scheduled completions date is the fall of 1962.

The Department of the Interior announced award of the first contract in the Department's new helium-conservation program which ultimately will conserve 52,000,000,000 cu ft of helium that otherwise would be wasted under current practices.

Small amounts of helium are present in some natural gases, and the program calls for its recovery by industry. The government will buy the helium and pipe it to underground storage fields to be withdrawn as needed.

Braden Copper Co. announced it has begun a \$6,000,000 project to increase the capacity of its copper facility at Rancagua, Chile, to 191,000 tons annually. The property is 65 miles southeast of Santiago. Ore body working levels are located between 8000 and 10,000 ft elevation.

Kaiser Engineers International will provide the engineering and technical services for the program which is expected to be completed by December 3, 1961.

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Annual Coal Division Conference

Pittsburgh, Pa., Friday, November 17, 1961

On Friday, November 17, the Coal Division of the American Mining Congress will hold its Annual Conference at the Penn-Sheraton Hotel in Pittsburgh. The various Coal Division Committees will report on their activities during the year and discuss plans for the future.

Primary purpose of the Coal Division is to study the practical application of mining machines and methods to determine what is required for successful operation under widely varying conditions. The eight Coal Division Committees meet regularly to discuss and evaluate advances in technology, and prepare reports to disseminate operating and technical information. Once a year, at the Annual Conference, all of the Committees meet to exchange ideas and to report on progress in individual studies—some completed and others in progress. All phases of coal production and preparation are covered.

The value of the Annual Conference as a source of information on the most recent developments in the technology of mining and preparing coal efficiently and safely is recognized far and wide. A cordial invitation is extended to all segments of the industry—including operating and technical mining men, manufacturers of mining equipment, and interested State and Federal agencies—to attend the Conference and participate in the discussion that is so vital in getting the most out of such a meeting.

Coal Division Committees which will participate in the Annual Conference, and their chairman, are:

Committee on Coal Mining Research

H. B. CHARMBURY
Pennsylvania State University

Committee on Roof Action

LONNIE D. ELLISON
Island Creek Coal Co.

Committee on Mine Power

JAMES A. ERSKINE
Eastern Gas and Fuel Associates

Committee on Mine Haulage

A. G. GOSSARD
Snow Hill Coal Corp.

Committee on Strip Mining

EDWIN R. PHELPS
Peabody Coal Co.

Committee on Coal Preparation

J. J. REILLY
Jones & Laughlin Steel Corp.

Committee on Mine Safety

W. G. TALMAN
U. S. Steel Corp.

Committee on Mechanical Mining

J. A. YOUNKINS
Duquesne Light Co.

ALSO . . .

Harvey Aluminum, Inc., is participating with Nova Scotia in a survey and study to determine whether an integrated aluminum complex in Nova Scotia is feasible. The Nova Scotian government has been accelerating its efforts to stimulate economic growth and attract industry in order to help offset the adverse effects of the decline in its coal mining industry which has been an important busi-

ness factor. Good port facilities and the availability of coal for power generation are regarded as conducive to establishment of an aluminum industry. It would also offer an outlet for considerable coal supplies, not to mention coal by-products.

Cleveland-Cliffs Iron Company's 800,000-ton-per-year expansion of pellet capacity at the Republic mine of the Marquette Iron Mining Co. is progressing on sched-

ule and should be in production early in 1962. Work has started on the next portion of the plant which will bring the annual capacity of Marquette to 2,300,000 tons.

Pilot plant tests for the initial unit of Empire Iron Mining Co. are underway and plant construction should start next spring. When completed, the initial unit is expected to have an annual capacity of 1,200,000 tons. Plant capacity will be expanded as needed.

Get DOUBLE EXPANSION for DEPENDABLE roof support with

PATTIN roof bolts and expansion shells



STYLE
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The unique double expansion feature of all PATTIN expansion shells insures dependable roof support, in hard or soft roof conditions. Their double holding power guards against failure — even under a 20 ton pull!

PATTIN features include a parallel contact with the hole, and no definite drilling depth is required, as the shell can be securely anchored at any place in the hole. They anchor solidly and will not turn while being tightened. Wedge and shell are assembled in a manner to prevent loss of parts in handling, and the bolt and shell assembly are furnished as a complete unit. Plates are bundled separately. No special nuts or ears are required on the bolts. These features make a safer roof — and a safer roof means fewer accidents, increased production, more clearance for equipment operation and better ventilation.

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foreign
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The PATTIN split-type BOLT

The split-type bolt is one of the first slotted bolts, and continues to be a favorite wherever split-type bolts are used. Many mines still prefer this type. The bolt is a full 1-inch in diameter, with cut threads and furnished with hex or square nuts and various size plates and wedges.

IN WESTERN STATES

PATTIN expansion shells are available and serviced exclusively by Colorado Fuel and Iron Corporation, Denver, Colorado. Western mining companies should contact them direct for information and consultation.

PATTIN

MANUFACTURING COMPANY
MARIETTA, OHIO

The PIONEER of roof bolting . . . established 1888

Barnes & Tucker Co. of Barnesboro, Pa., has purchased more than 2000 acres of coal land in parts of Indiana and Cambria Counties, Pa. The purchase, which includes mining rights, is for all the remaining coal of the lower Kittanning or "B" seam beneath the tract.

The anthracite industry has been advised by Defense Department procurement officials that the department has approved the use of anthracite for heating purposes in American military installations in West Germany. These requirements could soon reach 800,000 tons annually. In 1960 United States anthracite production totalled 17,453,000 tons.

"Radioisotopes—New Horizons in the Mineral Industries" will be the subject for discussion at the Annual AIME Off-the-Record meeting to be held at Pittsburgh's Penn-Sheraton Hotel on November 3, 1961.

North American Coal Corp. has leased about 82 acres of land near Armagh, Indiana County, Pennsylvania, for deep mining of coal. The company, according to an agreement filed in the County Recorder of Deeds office, will pay a royalty on production, or a minimum monthly rental.

The Fifth Annual Coal Technology Conference, sponsored by Southern Research Institute, Birmingham, Ala., will have as its theme this year, "Coal's New Horizons." The Conference will be held in Birmingham, October 3-4.

Subjects to be probed during the two-day session include coal versus atomic energy as a source of power, the case for electrification of railroads, the coal supply-demand situation, and the future for coal gas. New developments in coal-burning gas turbines, pipelines for transporting coal, coal chemicals, and underground gasification will also be discussed.

Ohmart Corp. is constructing a new 20,000-sq ft plant in Cincinnati. Ohmart is a manufacturer of nuclear gauging systems.

The 23rd Annual Mining Symposium of the University of Minnesota and the Annual Meeting of the Minnesota Section of AIME will be held jointly in Duluth, January 15-17, 1962. The three-day program is sponsored by the School of Mines & Metallurgy and the Center for Continuation Study of the University, in cooperation with the local section of the American Institute of Mining, Metallurgical & Petroleum Engineers. It will feature some 20 technical papers at six sessions covering the following subjects: Beneficiation and Agglomeration of Taconites, Magnetic Roasting and Metallized Pellets, Blast Furnace Performance with Agglomerates, and New Developments in the Exploration, Mining, and Beneficiation of Iron Ores.

Details regarding the program and registration may be obtained by writing the Director, Center for Continuation Study, University of Minnesota, Minneapolis 14, Minn.

St. Joseph Lead Co. is closing its Bonne Terre lead mine in southeastern Missouri after nearly 94 years of operation. The decision was caused by low prices of lead and the improbability of substantial improvement, according to company spokesmen. The mine has been producing about 1800 of about 23,000 tpd of lead tons mined by the company in southeastern Missouri.

MINING CONGRESS JOURNAL

THE REPORT CORNER

Recent Publications of Interest to Mining Men

USBM RI 5735. "Process Development in Removing Sulfur Dioxide from Hot Flue Gases (In Four Parts), 1. Bench-Scale Experimentation," by D. Bienstock, J. H. Field, and J. G. Myers.*

USBM RI 5802. "Flotation of Unoxidized Manganiferous Material from the Cuyuna Range, Minn.," by F. W. Wessel, P. A. Wasson, and D. W. Frommer.*

USBM RI 5808. "Underground Gasification of Coal: Second Experiment in Preparing a Path Through a Coalbed by Hydraulic Fracturing," by J. P. Capp and others.*

USBM RI 5815. "Explosibility of Coal Dust in an Atmosphere Containing a Low Percentage of Methane," by John Nagy and William M. Portman.*

USBM RI 5817. "Experimental Smelting of Utah and Wyoming Iron Ores," by Nick Derick and J. P. Riott.*

USBM IC 8020. "Estimated Costs of Gasifying Coal in Place: A Study Based on Electrolinking and Hydraulic Fracturing Experiments of the Bureau of Mines," by Sidney Katell and John H. Faber.*

* Available from Publications Distribution Section, Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Pa.

USGS Professional Paper 311. "Geology of Northeasternmost Tennessee," by Philip B. King and Herman W. Ferguson, "Description of the Basement Rocks," by Warren Hamilton. For sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

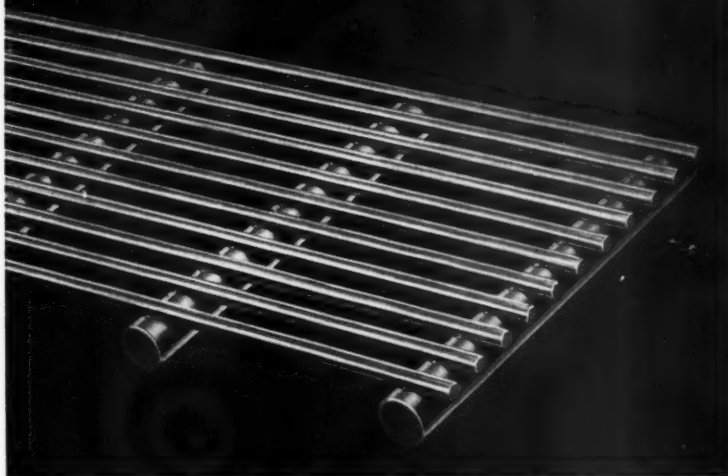
USGS Bulletin 1111-B. "Field Description and Sampling of Coal Beds," by James M. Schopf. For sale by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

USBM RI 5670. "Lake Superior Iron Resources," by R. L. Marovelli and others. Superintendent of Documents, Government Printing Office, Washington 25, D. C. Price 30 cents.

USBM RI 5790. "Experimental Extraction of Gold and Silver from California and Nevada Ores," by A. L. Engel and H. J. Heinen. Superintendent of Documents, Government Printing Office, Washington 25, D. C. Price: 30 cents.



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NEWS and views



Will Experiment with Hydraulic Mining of Coal

A large-scale research project to determine whether coal in the State of Washington can be mined hydraulically will be undertaken as a joint venture of the Bureau of Mines and Northern Pacific Railway Co. The experiments will be conducted in the company's mine at Roslyn, Wash. Hydraulic mining is sought as the answer to difficult problems in producing coal from "steeply pitching" beds encountered in the Roslyn mine and other mines in Washington.

Development of coking coal deposits in other areas in Washington is said to be intimately related to the success of the project. It was recently announced that the Mt. Rainier Coal Co. signed a contract to ship 800,000 tons of coking coal from mines in Pierce County, Wash., to Japan, and that hydraulic mining is being considered as the extraction method.

The Bureau of Mines has studied hydraulic mining of bituminous coal in a mine in central Pennsylvania where the coalbed is nearly horizontal. In the Roslyn mine experiments, a pump capable of supplying water at pressures up to 4500 psi will be installed. The nozzle output will be about 40 gpm. The Pennsylvania tests showed that eastern bituminous coals broke readily at lower pressures, but with larger volumes of water.

Simultaneously with disclosure of the coming project, USBM Director Marling J. Ankeny said the Bureau has begun a similar hydraulic project in Pennsylvania's anthracite region, also characterized by steeply pitching beds and faced with the difficulty of using conventional mining machinery. The anthracite test will involve pressures of 5000 psi and 300 gpm of water.

Tungsten Refinery Planned

New Idria Mining & Chemical Co. has announced plans to build a new refinery for the production of metallic tungsten and tungsten chemicals. The plant will process the company's own high grade ore and custom concentrates from domestic and foreign ores. New Idria has awarded a contract to Stearns-Roger Manufacturing Co. to design, engineer and construct the refinery. The basic process and operational procedures were developed through a research project at Colorado School of Mines Research Foundation in cooperation with New Idria and Stearns-Roger engineers. The company's announcement states that the refinery will make it a major producer of tungsten metal.

Oregon Coal Deposits Being Studied

Pacific Power and Light Co. is investigating coal deposits in Squaw Basin near Eden Ridge, Coos County, Ore. The company has obtained prospecting rights on 1800 acres which lie south of coal deposits on Eden Ridge to which the company already has mining rights. The Eden Ridge deposits were mapped during 1956-1957.

Surface reconnaissance has resulted in finding a negligible amount of surface exposure of coal deposits and the company is now core drilling in the basin area. PP&L has plans to erect a steam-electric power plant to serve southwest Oregon and in this connection holds mining rights on 5000 acres of Forest Service land where two veins of sub-bituminous coal have been mapped.

To Reopen Butterfield Mine

United States Smelting Refining & Mining Co. and Kennecott Copper

Corp. have reached an agreement to reopen and develop the Butterfield lead-zinc mine in the Lark-Bingham district of Utah. The mine, which is owned by Kennecott, was last worked in 1955. It is adjacent to U. S. Smelting's U. S. and Lark mines.

Plans call for driving a 1450-ft drift on the 1400-ft level in the U. S. section of U. S. and Lark mine and later connecting the lower levels of the Butterfield with this drift by a shaft or raise. In this way the intervening country can be explored and the costs of renovating the old entrance and shafts will be avoided. Several dewatering holes will be drilled into the Butterfield prior to connecting the new drift and mine. The project will take about 2½ years to complete.

ALSO . . .

Kermac Nuclear Fuels Corp. plans to drill six new ventilation holes averaging 780 ft in depth at its uranium mines in the Ambrosia Lake district of New Mexico. The holes, which will be capable of providing 70,000 to 75,000 cfm of additional air to working faces and drifts, will be cased with 42-in. casing.

Forty-one mining claims in the Lone Star Mining District near Saford, Ariz., have been patented by Kennecott Copper Corp. Said to be one of the largest groups of mineral claims to be taken in patent in Arizona in recent years, the claims are a portion of Kennecott holdings in the district where the company is engaged in a major exploration program.

Inspiration Consolidated Copper Co. has completed the McDonald shaft at its Christmas mine at Christmas, Ariz. The shaft is 1780 ft deep. The company is now driving a 1600 ft level main haulage drift toward the development shaft and ore body, while two headings are being driven from the development shaft and ore body toward the McDonald. Progress in one of these latter drifts is slow because of water difficulties. The company reports that construction of crusher buildings, fine ore storage and the conveyor system are nearing completion, and that heavy crushing machinery has been installed.

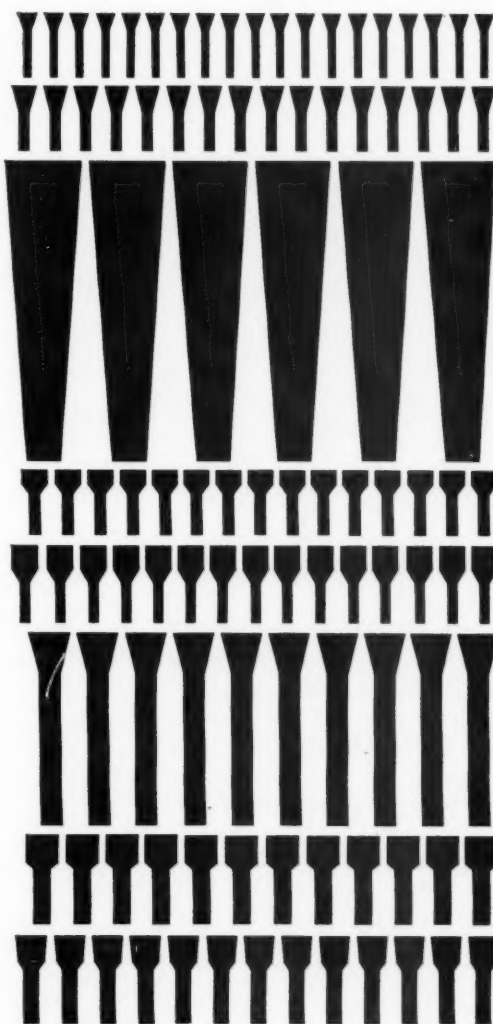
Hunting Geophysics, Inc., has been granted a three-year mineral exploration contract on the Papago Indian Reservation in Arizona. The contract had been under negotiation for several months. The Papago Indian Agency recently called for bids for exclusive prospecting permits on three additional tracts of tribal lands totaling 47,000 acres.

An operating agreement between Federal Resources Corp. and Silver Star-Queen Mines Inc. has been signed. According to the agreement, Federal will serve as operator of the Silver Star properties near Bellevue, Idaho, and will have a 60 percent interest in them. Initial plans of the company call for 1500 ft of cross-cutting and drifting in the Queens mine and geological work in the Minnie Moore mine.

International Minerals & Chemical Corp. plans to expand its Esterhazy, Saskatchewan, potash mine, which is expected to be brought into production next summer with an initial capacity of 420,000 tons per year. The expansion will permit production of about 1,200,000 tons per year.

Supplementary Information from Readers—

... Concerning the article, "Modern Theory of the Electrical High Tension Process," by R. E. Barthelemy, **Mining Congress Journal**, March 1961. The article credited H. B. Johnson as being the "father of this technique" and stated that "all of the machines that are on the market (Sutton, Lurgi, Carpc, etc.) are very similar to the original Johnson machine. . . ." Readers H. L. Bullock, engineering consultant, and G. W. Jarman, president, Separations Engineering Corp., have written to **Mining Congress Journal** commenting that these statements are in error; that others are deserving of the credit which the article gives to Johnson, and that Johnson himself, in the September and October 1938 issues of **Engineering and Mining Journal**, called Charles H. Huff the "grandfather" of electrostatic separation. In the September article, Johnson differentiated between the Huff separators and the Sutton, Steele & Steele separators. Johnson said that the latter "used pin-point, screen, or sharp edge electrodes adjacent to an electrified belt-conveying surface or drum. . ." while the Huff machine used "round smooth-surface electrodes and the gravity repulsive action." Reader Bullock pointed out that Johnson's work was predominantly concerned with smooth-round electrodes of the type used on the Huff machine. E. C. Ralston, in his book, "Electrostatic Separation of Mixed Granular Solids" (Elsevier Publishing Co., 1961—distributed by D. Van Nostrand, Princeton, N. J.), devoted seven pages to a history of the development of electrostatic separation techniques, listing dates and naming individuals who played important roles.



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Hendrick Wedge Slot Screens are available in a complete range of sizes, with profile bars that are precision engineered to meet a wide diversity of screening requirements. Designed to insure maximum dewatering efficiency and resistance to abrasion, Hendrick Wedge Slot Screens have parallel head flanges that maintain uniformity of openings throughout the life of the screen. Wedge Slot is available with profiles specially designed for heat dryers; dewatering following washboxes; water and sewage filtration; washbox bottoms; and coal, ore or sludge dewatering applications. For information on Hendrick Wedge Wire's free clearance, rugged mechanical strength, extra load carrying capacity and large percentage of open area, write Hendrick direct.

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ADV-174A

Mount Isa Mines Ltd. plans to install three large friction type hoists at its new K57 shaft in Australia. The equipment will include a completely automatic, 12,000-hp skip hoist with 800 tph capacity, a 6400-hp cage hoist, and a 700-hp auxiliary hoist which will operate similar to an elevator by means of push buttons. The hoists will be installed in a 200-ft headframe to service the shaft, which is planned for an ultimate depth of 4000 ft. Erection of the headframe structure is to begin next fall with completion of the entire project slated for the spring of 1964.

Capacity of the Clarkdale, Ariz., cement plant of Phoenix Cement Co. has been increased to 2,600,000 tons through completion of construction of a third kiln, which was placed in operation in July. Phoenix is an operating company of American Cement Corp. Riverside Cement Co., another operating company, has begun shipments of white cement. The Riverside plant is the only white cement facility in the west.

Mining and milling operations at the Copperopolis, Calif., asbestos property of Jefferson Lake Asbestos Corp. are scheduled to begin in March 1962. The company, which is 77 percent owned by Jefferson Lake Sulphur Co., has contracted with Wells Cargo, Inc., to mine and haul the ore. Jefferson Lake Asbestos is building a mill and other facilities at the property, having recently completed \$7,000,000 of financing for the project.

A ten-year contract involving the sale of 10,000,000 long tons of iron ore has been signed by Kaiser Steel Corp. and Mitsubishi Shoji Kaisha Ltd. of Japan. Kaiser will produce the ore at its Eagle Mountain, Calif., mine and ship it by rail to Long Beach. There it will be loaded on 50,000-ton ore vessels for shipment to Japan. First shipments are expected to be made in the latter part of 1962.

Kennecott Copper Corp. is undertaking a deep drilling program in the Robinson Mining District of White Pine County, Nev. The company's Nevada Mines Division is located in White Pine County where current plans call for drilling to at least 3000 ft in the most favorable remaining area. Expenditures this year for the program will amount to about \$300,000. If findings are favorable, it is expected that the exploration program will extend over several years.

Sinking of the shaft at the Conjecture Silver mine in North Idaho from the 1000 to the 2000 ft level was scheduled to have been completed in August. As of July 15, it had been deepened to more than 1800 ft. With completion of the shaft, crosscutting and drifting to reach the mine's ore zone will be conducted. First results of this project should be known late this year. The mine is being developed by Federal Resources Corp., which has already established a commercial ore body at the property.

The vertical shaft of the Anaconda Company's Mountain Con mine at Butte, Mont., has reached a depth of one mile, extending from an elevation of 6081 ft at the surface to 801 ft above sea level at the bottom.

The mile mark was reached on the 97th anniversary of the first recorded lode location in the Butte district. The shaft sinking is part of the company's plan to prepare for the mining of copper ore from deeper levels in Butte.

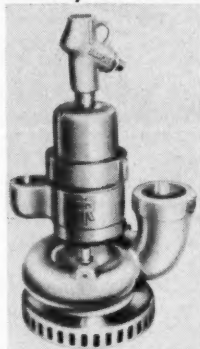
The Mountain Con, one of Butte's oldest mines, was started about 1876 as a silver producer and subsequently became a great copper mine. It was acquired by Anaconda in 1895. In 1899 the shaft was down 2000 ft and it has been deepened at intervals since. Because of its depth two-stage hoisting started in 1952 with the installation of an engine room on the 4000 ft level. Ore from below this level was first hoisted to the 4000 ft and then to the surface. About 600 men are presently employed at the mine.



manufacturers forum

AN AIR-OPERATED SUMP PUMP, which can be carried by one man and operated on a moderately low volume of air, such as

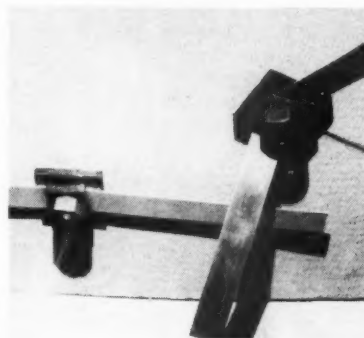
supplied by a small portable compressor, has been announced by Ingersoll Rand Co., 11 Broadway, New York 4, N. Y. The new Size 225 Sump Pump handles clear or dirty water, oil, sewage, or light sludge. This pump is only 16¼ in. high, including air strainer, and will pass through an opening only 7½ by 9⅜ in. The 33¾-lb pump has a rated water delivery at 90 psi from 197 gpm at a 10-ft head, to 68 gpm with an 80-ft head, and is powered by a governed Multi-Vane motor, preventing pump damage if the sump is pumped dry.



the engine running at 2200 rpm. Special low-range speeds permit efficient casing rotation, rock biting, soil sampling and other applications requiring slow rotation speeds.

All controls are grouped at the operator's fingertips. Capacity of the "38" is 2800 ft with AW rods or 1750 ft with NW rods.

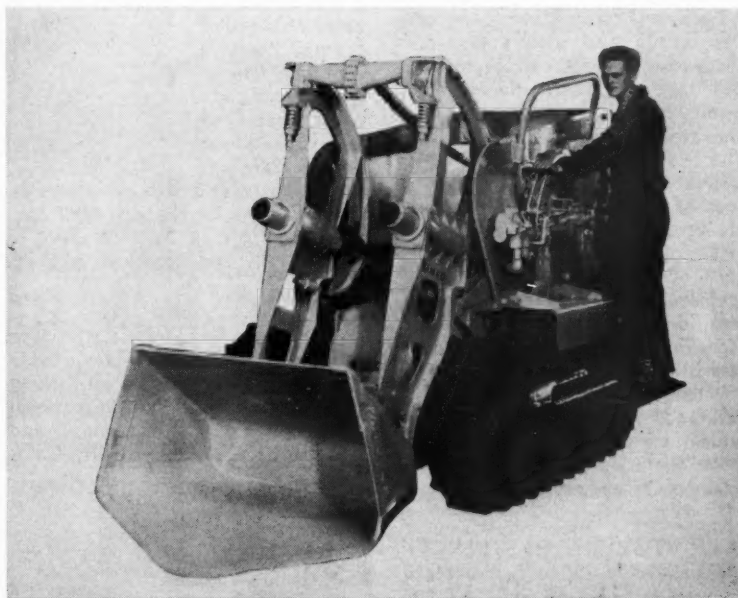
A SAFETY INDICATOR for use with roof bolts to give indication of imminent cave-ins has been made available by Ladd & Little, Inc. of Huntington Station, N. Y. The purpose of the simple device is to increase mine safety by giving a direct and immediate indication of dangerous loading on a roof bolt. This is



done by the use of a washer, a shoe, and a two-foot long aluminum indicator flag. The flag droops as the roof bolt load increases.

A ROOF BOLTING MACHINE, the Model LRB-7, has been added to the line of mining machinery from Long-Airdox Co., Oak Hill, W. Va. The new machine is larger and faster than the earlier Model LRB-2, but has the same height of 27 in., permitting its use in thin coal seams. It has a maximum arm lift of 60 in. and drills at 430 rpm. The vertical stroke of the drilling unit is 60 in. Trimming speed is 190 fpm. Two 15-hp mine-duty type motors drive the hydraulic pumps that power the new machine. The Model LRB-7 roof bolting machine is 13 ft long, 5½ ft wide, and has a ground clearance of 6 in. It weighs 7000 lb.

A DIAMOND DRILL, the Longyear "38," is being introduced by the E. J. Longyear Co., Minneapolis, Minn., and reportedly incorporates many exclusive features necessary to modern drilling techniques. The drill features an 8-speed transmission with spindle speeds of from 69 to 1850 rpm with



A NEW AND LARGER TRACTOR-EXCAVATOR has been added to the line of air or electric (a-c) powered underground loaders by the Eimco Corp., Salt Lake City, Utah. Designated the Eimco 631 Excavator, this crawler-mounted loader is a larger version of the Eimco 630 Excavator, affording higher discharge. It is able to load longer and larger trucks.

Tracks are longer and weight carrying capacity is increased with added track rollers. Standard discharge height is 8 ft in a headroom of 11 ft 2 in., with other discharge heights available. Discharge distance behind the rear of the machine is 19 in.; SAE bucket capacity 12½ cu ft; minimum overall height, 6 ft 5 in., and operating width, 5 ft 8⅝ in.

A SEAMLESS LEAK-PROOF CANISTER spearheads a list of exclusive features in the new line of gas mask respiratory protection just introduced by Mine Safety Appliances Co., Pittsburgh. The drawn canister removes potential sources of leaks, since side

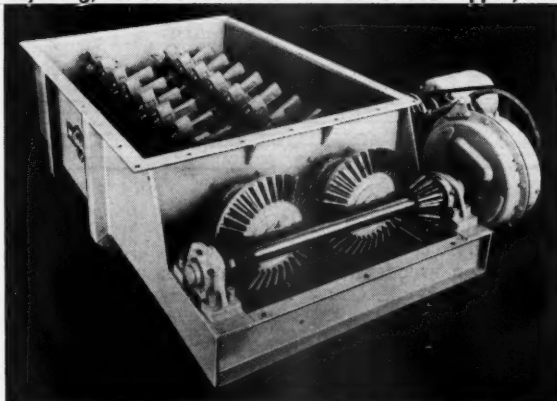


and top seams have been completely eliminated. The new line of masks also includes a totally different concept in harness design, and a rugged plastic case that is chemically inert and resistant to moisture. Every canister is equipped with a high-efficiency toxic dust filter which, together with the appropriate chemical fill, permits its use in gas and dust contaminated atmospheres. The special filter provides greater application flexibility and reduces the number of types of canisters necessary to provide protection against gaseous and toxic aerosols.

Use of the lightweight "Clearvue" facepiece—available with the new gas mask line—provides panoramic vision, a speaking diaphragm for clear communication, and provision for prescription spectacles. The M-S-A Maskfone, a sound-powered communications system ideally suited for remote operations, can also be adapted to the new facepiece.

A LIGHTWEIGHT, HI-STRENGTH PIPE WRENCH called Gripso-Matic and manufactured by Standard Fittings Co., 82 Herbert Street, Framingham, Mass., has been designed to provide instant adjustment to any pipe size. It can be snapped closed when not in use. A special spring loaded ratchet locking device is located inside the handle and the hook is calibrated from 1/2 in. to 2 in., which enables user to set wrench in advance. Available in sizes of 6, 8, 10 and 14 in.

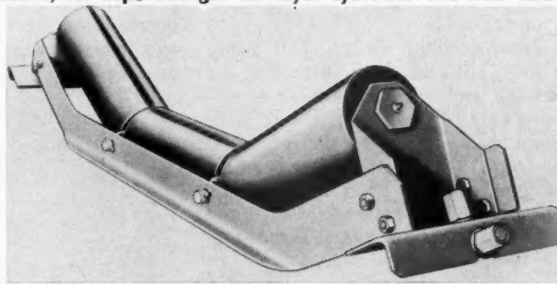
DESIGNED FOR CONTINUOUS CHOPPING OF CLAY AND ORE FEED IN PROCESSING SYSTEMS, the Clay Breaker has been introduced by McLanahan Corp., Hollidaysburg, Pa. Constructed to fit under a feed hopper, this machine continuously accepts feed from the hopper and cleaves it between a series of meshing paddles on each of two paddle shafts. The paddle action further keeps the feed agitated to provide a uniform flow of broken material from the machine to the conveyor.



Discharge is from the bottom. The McLanahan Clay Breaker can be custom-built to most any width or length requirement. The unit is completely self-contained, with box and drive mechanism and motor permanently mounted on a structural steel base. Power is provided by a 7 1/2-hp motor.

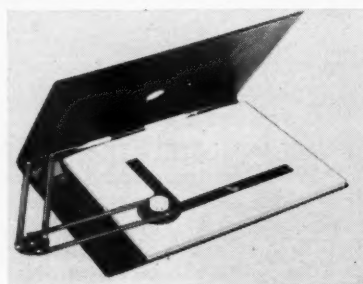
A TROUGHING IDLER, called Style L, is now being offered by Hewitt-Robins, Stamford, Conn., for rope stringer conveyor systems. The new idler

offers easy lubrication, with six bearings lubricated from one grease fitting, located at the idler frame. Positive wire rope attachment prevents idler movement and subsequent belt detraining,



and the fastener design eliminates damage to wire rope. Important design advantages cited for the new idler are: easy disassembly; special double-length nuts used for rope clamp; flanged side bars, furnishing sturdy frame support for idler rolls; and interchangeable idler rolls.

A SKETCH KIT, with a new type portable drafting machine mounted in a newly improved vinyl self-locking binder, is announced by the National Blank Book Co., Holyoke, Mass., and Draftette Co., Beverly Hills, Calif.



The portfolio fold kit includes the drafting machine, with a 3 x 5-in. or 4 x 6-in. scale and a 180° protractor,

a pad of 50 sheets of 8 1/2 x 11-in. drawing paper, and a pencil. The versatile kit is planned as a personal, portable machine for sketching, drawing, drafting and designing in the office, shop, home, school or field. The kit measures 9 1/2 x 13 x 1 1/2-in. and weighs 1 1/2 lb.

AN ALL-ALUMINUM DUMP TRUCK BODY, manufactured by the Penn Body Division of Hockensmith Corp., Penn., Pa., has been designed for its weight and cost savings properties, as well as its resistance to moisture and corrosion. Both the body and the chassis of the truck are aluminum. Load capacity is 35 cu yd. Approximate weight of the unit unloaded is 10,900 lb. The over-all length of the trailer is 28 ft. Potential pay load is in the 21-ton bracket.

—ANNOUNCEMENTS—

Donald G. Ashe, sales manager of the **Allen-Sherman-Hoff Pump Co.**, has been elected vice president of the company. Joining the company as sales engineer in 1954, he has been head of sales engineering since 1958.

H. DeForest Hardinge was appointed vice president, **Hardinge Co., Inc.**, and **Hardinge Mfg. Co.**, during a recent board of director's meeting.

Charles B. McCoy, general manager of the Du Pont Company's Explosives Department, has been elected a vice president, director, and member of the executive committee of the company. He succeeds **Robert L. Richards** who is retiring. **Dr. B. H. Mackey**, an assistant general manager of the Explosives Department, was appointed general manager of that department.

A. J. Perantoni, associated with American Cyanamid Co. since 1952, has been appointed advertising and promotion manager of the intermediates, explosives and mining chemicals, and the refinery chemicals departments. He will be located in the general sales offices of the division at Bound Brook, N. J. Perantoni joined the advertising department as a supervisor in 1953, and subsequently had advertising responsibilities for several product lines. Since 1958 he has been an explosives salesman in the eastern district sales office.

Hercules Powder Co. has announced two appointments in their Explosives Dept. **Henry V. Chase**, formerly manager of explosives operations in the department, becomes director of operations for the department's commercial explosives division, and **Albert R. Ely**, formerly assist-

ant to the explosives department's operations director, has been made industrial relations manager.

Mine Safety Appliances Co. is consolidating all basic and applied research, product development, and engineering in a newly-established corporate Research and Engineering Division.

Roger F. Mather, formerly with the Product Development Division of U. S. Steel Corp., has been appointed director of the Division. **Dr. W. P. Yant**, who has been in charge of the parent company's research activities for the past 25 years, will become research consultant to the president. Also appointed were three associate directors and a manager of administrative services to complete the executive direction of the new Division. These include: **J. W. Mausteller**, associate director-research; **R. C. Werner**, associate director-engineering and development; **J. P. Strange**, associate director-product engineering; and **D. N. Wise**, manager of administrative services.

Bruce O. Young has been named manager, Carbon and Alloy Specialties product division, **Crucible Steel Co. of America**. He has been with the company since 1956, joining it as market development coordinator.

Goodman Mfg. Co. has announced the appointments of **L. W. Peterson** as sales manager of its newly created U. S. Eastern Division and **L. S. Ahlen** to a similar position in its new Western Division which also includes Mexico, Canada and all overseas markets. Peterson has moved to Pittsburgh from his former post as manager of the company's Hunting-



R. F. Mather

ton, W. Va., sales district. Ahlen will remain at Chicago where he has been serving as assistant sales manager. Replacing Peterson at Huntington is **Sheldon Jones**, who advances from assistant district manager.

The appointment of **Earl E. Swansen** as manager of product planning and development has been announced by the Conveyor and Process Equipment Division of **Chain Belt Co.** In his newly-created position, Swansen will coordinate the division's product planning and product development program, and will also be responsible for the improvement of existing product lines.

A. G. Gilbert has been named sales engineer with **McNally Pittsburgh Manufacturing Co.**, with headquarters in the Chicago office. Gilbert, who has chalked up 16 years experience in coal preparation work, was previously a sales official with **Wilmot Engineering Co.**, and with **Heyl and Patterson, Inc.**

The promotion of **Seldon A. Stone** to drill sales manager has been announced by **Bucyrus-Erie Co.** He succeeds **George D. Grayer**, who has been appointed sales manager of the Midwestern Region. As drill sales manager, Stone is responsible for marketing the company's line of blast hole drills, water well drills and oil spudders. He formerly was assistant drill sales manager and previously served for five years as sales manager of oil and water well drills.

Darrell E. Albert has been named manager, Chicago District Sales Office of **Mine Safety Appliances Co.** He was formerly product line manager of gas masks and respirators at the company's headquarters. He replaces **C. R. Dever** who has been transferred to Pittsburgh as manager of sales promotion.

CATALOGS & BULLETINS

BREATHING APPARATUS. *Mine Safety Appliances Co., 201 North Braddock Avenue, Pittsburgh 8, Pa.* Bulletin No. 0101-1 describes a self-contained oxygen breathing apparatus, specially designed for rescue work, and a transistorized communication system for rescue team-fresh air base liaison. The two-hour McCaa breathing apparatus, available with a mouthpiece type mask or All-Vision facepiece, supplies respiratory protection in poisonous or oxygen deficient atmospheres. The unit features an oxygen admission valve that automatically meets wearer exertion requirements, a positive pressure circulatory system, an efficient

Cardoxide absorbent, and a one-piece, leak-proof cooler and regenerator. Battery-powered, the portable communication system includes microphones, amplifiers, loudspeakers, 500-ft reels of two-conductor wire, and a two-conductor heavy team guide line.

TEMPERATURE REGULATORS. *OPW-Jordan, 6013 Wiehe Road, Cincinnati 13, Ohio.* The 8-page Temperature Regulator Catalog, TCV-1, is fully illustrated and contains complete engineering information and technical data on OPW-Jordan's line of Temperature Regulators, which are available in self or pilot-operated models from 1/4 through 6-in. sizes. The catalog shows cutaway pictures, features, names of parts, ratings, dimensions,

applications, operation, ranges, materials of construction, sample specifications, flow curve and sizing charts.

PULLEYS. *Stephens-Adamson Mfg. Co., Aurora, Ill.* Bulletin 1160 describes the new one-piece steel "Curve Crown" pulleys, featuring exclusive spun-end construction recently developed by Stephens-Adamson. All end plate weldments have been eliminated in the fabrication of the new spun-end pulleys, according to Stephens-Adamson engineers, thus eliminating principal sources of metal fatigue, stress, and other trouble. The new brochure also describes the "Squeeze Lock" hub which exerts equal locking forces in two directions, to both the shaft and pulley end plates.

(Continued on next page)

Catalogs & Bulletins

(continued from previous page)

SPIRAL BEVEL SPEED REDUCERS. *Department SR, Hewitt-Robins, Stamford, Conn.* Bulletin J-25 contains the latest information on Jones horizontal and vertical spiral bevel speed reducers. Data includes information on: basic types; special features of vertical types; applications; selection procedure; overhung and thrust load capacities; standard assemblies; horsepower and thermal ratings; general dimensions; backstop selection, and bedplate

DRILLING RIGS. *Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y.* A 20-page booklet, Form 4215, covers special rock drilling rigs for mining, tunnelling and construction work. It shows many on-the-job photos of special rigs engineered to meet exact requirements of each job. The booklet is designed to show how mines and contractors can create special drilling rigs to meet their own particular problems using Ingersoll-Rand components.

FILTRATION. *Snow Filtration Co., Dept. R., Cincinnati 2, Ohio.* Companies interested and involved in the processes of filtration, dust collecting, air conditioning, air pollution control and sieving, sifting and straining will find useful this Reference Manual which indexes articles on these various subjects.

SHUTTLE CAR. *Goodman Mfg. Co., Halsted St., and 48th Place, Chicago 9, Ill.* The 1070 Shuttle Car which comes in heights of 44 and 49 in. and widths of 96 in. with 39-in. conveyor, and 106 in. with 49-in. conveyor, is described in Sheet G-140.

It is a 4-wheel drive car able to carry 10 tons at 5 mph and empties its load at high or low speed from an adjustable height discharge conveyor. The descriptive sheet includes diagrams and specification tables of each style of car.

HOPPER-LOADER. *The Eimco Corp., P. O. Box 300, Salt Lake City 10, Utah.* Included in Bulletin L-1155 are many pictures and detailed facts of the Eimco 631 Hopper-Loader, a crawler mounted loader, as well as complete specifications on this air or electric (a-c) operated unit, which has a load carrying capacity of 56 cu ft. The model 631 can tram to a mill hole and return to the muck pile without turning. Over-all operating width is 5 ft 8½ in.; height 6 ft 5½ in. and weight is 15,500 lb.

PRE-ENGINEERED STRUCTURES. *Building Div., The Parkersburg Rig and Reel Co., Parkersburg, W. Va.* Brochure No. BD-260 describes the self-supporting A and AL Series, and Standard Shed pre-engineered metal buildings designed to meet small building requirements. The flexibility of design, economy and ease of construction of these weather-tight buildings is illustrated as well as building specifications and their various applications.

LUBRICATION EQUIPMENT. *Lincoln Engineering Co., Industrial Sales Div., 4010 Goodfellow Blvd., St. Louis 20, Mo.* Featured in the 32 Page Catalog No. 82, is the company's complete line of lubricant application equipment with descriptions of fully automatic, semi-automatic and manual methods of operation. High and low pressure lubricant injectors, timing and alarm controls and filler pumps are described along with several pages of installation accessories.

NON-METALLIC BACKING AGENT. *Nordberg Mfg. Co., Milwaukee, Wis.* Just Mix and Pour is the title of a new bulletin from the company presenting the story of Nordback which is used in gyratory crushers, grinding mills and other machinery where backing agents are used. Shown and described are the safe, simple procedures for backing crusher members right on the job.

CHEMICAL REAGENT ANALYZERS. *Scientific and Process Instrument Div., Beckman Instruments, Inc. 2500 Fullerton Road, Fullerton, Calif.* The Beckman Air Pollution Analyzers, designed specifically to monitor and record low concentrations of oxidants, oxides of nitrogen, or sulfur dioxide in the atmosphere, are described in Bulletin-K-4023. There are three models, K-75, which is installed in a standard 19-in. enclosed relay rack on casters; K-76, installed in a special aluminum cabinet on casters; and K-78 equipped for performing one analysis. There is also a portable model.

COAL MINING BITS. *Vascoloy-Ramet Corp., Waukegan, Ill.* Latest improved coal bit designs are featured in Catalog number V-489, with specila charts and drawings to indicate the dimensions of each bit for selection of proper size and style. Also shown is V-R's complete line of carbide-tipped percussion bits.

STEEL BELT CONVEYORS. *Sandvik Steel, Inc., 1702 Nevins Road, Fairlawn, N. J.* The company has available an eight-page, two color booklet replete with photos and line drawings illustrating applications and features of steel belt conveyors. Entitled "For All-Round Use," the booklet was originally prepared for distribution following a Sandvik movie which is still available for loan.

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★ ★



Artist's sketch of new cleaning plant, Federal No. 1 Mine, Grant Town, West Virginia

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For detailed information, contact your MSA Representative. Or write, Mine Safety Appliances Company, 201 N. Braddock Avenue, Pittsburgh 8, Pennsylvania. In Canada: Mine Safety Appliances Company of Canada Ltd., 500 MacPherson Avenue, Toronto 4, Ontario.

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